JOURNAL OF DENTISTRY FOR CHILDREN

Published by

The American Society of Dentistry for Children

Alfred E. Seyler, D.D.S., Editor
18557 East Warren Avenue, Detroit 36, Michigan

Editorial Board

Basil Bibby — Manuel M. Album — Gordon Rovelstad

Contributing Editors

Maury Massler — Kenneth A. Easlick — Manuel M. Album
William F. Via, Jr. — Zalman Konikow — Ralph L. Ireland

Issued quarterly in March, July, September and December at 1201-05 Bluff Street, Fulton, Missouri. Subscription price $5.00 per volume (four issues); to members of the A.S.D.C. $2.00 per volume. Single copies $1.25. *Changes of address should be sent to the business office, 13201 Miles Ave., Cleveland 5, Ohio.* Entered as second class matter at the post office at Fulton Mo.

Publication in the JOURNAL OF DENTISTRY FOR CHILDREN is not to be taken as an endorsement by the Publishers, the Editors or the Editorial Board.

VOLUME XXVI — *Third Quarter, 1959* — NUMBER 3

CONTENTS

Topical Fluorides—Symposium
A Public Health Dentist Looks at Topical Fluorides Today, *Donald J. Galagan, D.D.S., M.P.H.* . . . 164
Present Status of Topical Fluoride Therapy, *Joseph C. Muhler, D.D.S., Ph.D.* . . . 173
Action of Topically Applied Fluoride, *Finn Brudevold, D.D.S.* . . . 186
Dentin Dimensions of Primary Teeth, *Sumter S. Arnim, D.D.S., Ph.D. and Millard P. Doyle, D.D.S., M.S.* . . . 191
Preliminary Program, 1959 Annual Meeting . . . 215
The Organization of Effective Community Dental Health Programs, *Wesley O. Young, M.D., M.P.H.* . . . 220
Health Education Activities in Community Dental Programs, *Perry Sandell* . . . 224
Contributions of Community Dental Programs to the Practice of Dentistry for Children, *Robert L. Weiss, D.D.S., M.P.H.* . . . 228
Provision of Dental Care in Community Dental Programs, *J. M. Wisan, D.D.S., M.S.P.H.* . . . 233
Unit News, *Tiny Konikow* . . . 238
The Acrylic Mouthpiece for Poliomyelitis and Cerebral Palsy Patients, *Robert R. Buckley, D.D.S.* . . . 248
Measurements of the Primary Teeth, *William S. Kramer, D.D.S., M.S. and Ralph L. Ireland, D.D.S., M.S.* . . . 252
Pharyngeal Occlusion in a Child Relieved by Dental Appliances—A Clinical Report, *R. C. Haskins, D.D.S., M.S.D.* . . . 262
The Preservation of Deciduous Teeth—(Published 1849) . . . 267
State Unit Secretaries . . . 271
Officers and Committees A.S.D.C. . . . 272
Abstracts . . . 273
Book Review . . . 374

Topical Fluorides—A Symposium

EDITOR'S NOTE:

The three papers following were presented at a Joint Anniversary Meeting of the New York Society of Dentistry for Children and the Eastman Dental Dispensary, at Rochester, New York in April 1958.

As Doctor Galagan expresses it—"It is high time we re-examine the need for a caries preventive such as topical fluoride applications. Although this procedure was shown to be effective more than ten years ago, dentists in private practice and administrators of public health and school dental programs have put the measure to very limited use."

You will be wise to read the papers presented and possibly re-evaluate your own office policy regarding topical fluorides.

A.E.S.

PARTICIPANTS

DONALD J. GALAGAN, D.D.S.

JOSEPH C. MUHLER, D.D.S.

FINN BRUDEVOLD, D.D.S.

A PUBLIC HEALTH DENTIST LOOKS AT TOPICAL FLUORIDES TODAY

DONALD J. GALAGAN, D.D.S., M.P.H.*

IN its testimony before the United States House of Representatives in 1948, the American Dental Association stated that topical fluoride treatments should be used routinely in private dental offices and in school and community dental health programs. The Association's testimony embodied a forthright expression of support of the nationwide demonstration then getting under way, and a hopeful desire that topical fluoride treatments would be used extensively to combat dental caries among the nation's children.

Let's look at the record ten years later. Topically applied fluorides are not being utilized widely as a caries preventive. Although this procedure was shown to be safe and effective well over a decade ago, in the ensuing years, dentists in private practice and administrators of public health and school dental programs have put the measure to only very limited use. It is high time we re-examine the need for a caries preventive such as topical fluoride. We need to take a look at its potential usefulness in terms of the need, evaluate the factors which appear to have influenced its acceptance in the past and make some plans for future action.

Topical fluoride treatments cannot be

* Assistant Chief, Division of Dental Public Health, Public Health Service, Department of Health, Education, and Welfare, Washington 25, D. C.

evaluated without also considering the fluoridation of community water supplies. Water fluoridation is the most efficient and effective known method of preventing dental caries. However, fluoridation has not been, and is not likely to be, available to all segments of the child population. Currently, about 1600 communities are providing almost 35 million people with fluoridated water.[1] In view of the slow but steady increase each year in water fluoridation programs, there has been a general assumption that there was a parallel decrease in the number of children needing some alternate kind of caries protection. However, in spite of the gains in the extension of caries control programs through the fluoridation of community water supplies, there still is a great need for a dental caries preventive such as topical fluorides.

Due to the postwar baby-boom, the numbers of children 5-16 years of age who were not drinking fluoride-bearing water has increased rather than decreased during the last 12 years. Figure I shows the number of children at ages 3, 7, 10, and 13 not on fluoridated water. The left hand bar of each pair represents the number of children in the age group in 1945, the one on the right, the number of children in each group in 1957. Except for age 13, the number of children in each age group who were not protected by water fluoridation was greater last year than it was in 1945.

The total population, ages 5-16, not on fluoridated water during the years from 1945 to 1957 is shown in the insert in the upper right hand corner of the figure. As you can see the total number of children in these ages who were not receiving the benefits of fluoride-bearing water has increased from 25,000,000 in 1945 to 29,000,000 in 1957. The increase in community water fluoridation programs has not kept pace with the increase in the young population.

These facts, then, establish the basis for our discussion. Right now there are approximately 29,000,000 children living in areas where the water does not con-

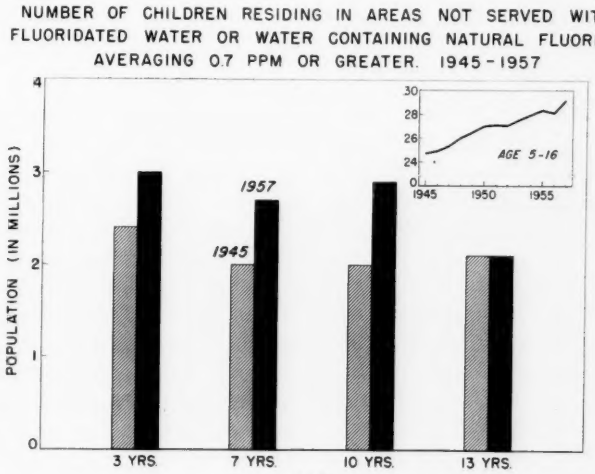

Figure I

tain fluorides and who consequently need some other form of protection against dental caries attack. Obviously there is a need for widespread utilization of a preventive technique which can be used in the private practice of dentistry and in school and health department dental programs in communities and rural areas where fluoride-bearing water is not available.

The evidence that a topical fluoride solution will prevent dental caries has continued to increase since Dr. Bibby first reported his observations in 1942.[2] Findings here at the Eastman Dental Dispensary,[3-6] the studies conducted by the Public Health Service,[7-14] the more recent developments by the Indiana group,[15-23] and reports from literally hundreds of scientists throughout the world all add up to a very impressive documentation of the potential which topically applied fluoride agents have for preventing caries. It is clear that the place of topical fluorides in today's caries prevention program should be very important. It has use in all rural areas, in all communities not yet fluoridating their water supply, and, in a more limited way, in those communities already supplementing the fluoride content of their water. Any technique which will reduce the incidence of new caries by 40 per cent—or 60 per cent—or even 20 per cent, should be used as widely as possible.

The present utilization of topically applied fluorides in private dental offices is not known accurately. The 1950 Survey of the Dental Profession conducted by the American Dental Association showed that less than 4 per cent of the patients under 20 years of age, who were seen by dentists during the week of the survey, were given topical fluoride treatments.[24] Applying the American Dental Association's reported percentage of children receiving topical fluoride treatments in 1950 to today's population, one finds that each year approximately 850,000 youngsters in the United States might be getting topical fluoride treatments from their own dentists. This figure is a very rough estimate, based on a 1950 report and may be in error by several hundred thousand children. Even though the absolute numbers of children treated in private dental offices today is not known precisely, the number receiving protection may be presumed to be extremely small in relation to the population in need. Obviously, the number cannot possibly be anywhere near the 29,000,000 children who are not consuming fluoride-bearing water.

Strangely enough, official health agencies, which should have utilized topical fluoride therapy to its fullest potential, have not achieved an admirable record. In 1956, a total of 31 of the 53 State and territorial health departments reported that they conducted some type of topical fluoride program.[25] The exact number of children treated in these health department programs, again, is not known. However, since the financial support for their total programs is so minimal, and the number of personnel is so limited, we can assume that relatively few children are reached through topical fluoride treatment programs sponsored by official State health agencies.

The extent of topical fluoride treatment in school programs is even less clear although perhaps the number of children reached through these auspices is larger than in any other group. According to a report of a study conducted by the American School Health Association in 1951, there were topical fluoride

programs conducted in a total of approximately 900 school systems in the United States.[26] The precise number of children treated was not reported.

A very rough estimate from these data from State and local health departments and school systems indicates that somewhere in the neighborhood of 750,000 children may be given topical fluoride treatments each year under the auspices of official agencies. Add to this figure the estimate of 850,000 children treated by private practitioners, and it appears that approximately 1,600,000 children may be receiving topical fluoride applications, annually. Thus, 16 years after the treatment first was reported in the literature, and a decade after the formal approval of topical fluoride therapy by the American Dental Association, it seems evident that relatively few children are receiving its benefits in relation to the total number of youngsters who could benefit by treatment.

It seems to me that a variety of interrelated factors have been responsible for retarding the acceptance of topical fluorides. Let me highlight a few of these factors which seem to be the most important.

The treatment has been quite expensive. The 2 per cent sodium fluoride technique, requiring a series of four treatments, is relatively time consuming. If the dentist provides the treatment himself, he has to obtain a fee which will reimburse him adequately for his very expensive professional time. Unfortunately, the profession generally has insisted that topical fluoride treatments be given by a dentist. Ironically, topical fluoride therapy can be provided just as well by a dental hygienist, or by even lesser trained personnel. Yet last year the Bureau of Economics and Statistics of the American Dental Association reported that approximately one-third of the States do not legally permit the dental hygienist to apply topical fluorides.[27]

The net effect of these restrictive policies and practices has been to increase the cost of topical fluoride treatment to the patient, make it less available because of manpower limitations and generally bring about less than adequate use of an effective therapy in private practice and in public health programs.

Next, I believe there has been real apprehension on the part of the practicing dentist about asking a fee for a service which is as intangible as topical fluoride application. This problem is related inherently to the public's traditional concept of obtaining a piece of "work" from the dentist, rather than the purchase of knowledge, advice or professional judgment. With the development of topical fluoride therapy in 1948, the whole profession was confronted for the first time with providing a specific preventive service, the value of which the purchaser could not assess. The patient had to trust completely the dentist's reputation and integrity for value received. The treatment could not be identified by the patient as a tangible filling, a denture, or even a clean mouth. There were no immediate values by which the patient could judge topical fluoride—and this concern on the part of the patient retarded its use.

Somewhat related to the problem just described is the very real one of assessing the true value of topical fluoride treatment in prevention for the individual patient. As all of you know, the percentage reductions in new carious lesions have resulted from studies in groups children. The translation of group findings for a treatment which is less than

100 per cent effective to predictions of results for a single individual is extremely difficult. Since caries continues to occur, one can only predict that the level of caries activity will be less after topical fluoride treatment than it would have been if the therapy had not been applied, but the particular level in each instance must be related to the individual's variable susceptibility and resistance. This concept is an extremely complex one to present to patients and creates serious interpretive problems, especially for the practicing dentist.

Related to the same basic problem is the fact that the treatment can result in failure even though the solution itself is effective when applied correctly. The technique is an exact and precise one, and if carried out improperly, does not work. I might use an example in the field of operative dentistry to illustrate the point. The alloy itself is not discredited if a fracture occures at the neck of a two surface amalgam restoration when, in fact, poor cavity preparation did not allow for sufficient bulk of material at that point. The reason for the failure must be attributed to poor technique on the part of the operator, not to the material itself. The same kind of failure can and does occur with topical fluoride treatments, yet the tendency in these instances has been to blame the solution rather than the technique used for application. However, such failure offers another reason for the limited use made of topical fluoride therapy.

These last several ideas suggest that relatively few dentists really know how fluorides should be applied, about how they may be abused. How many dentists for instance, are getting and using technical information about "easy" ways to apply fluorides from their dental supply salesman who has a special tray, a paste or some other "gimmick"? No wonder there is rather extensive doubt and confusion about the use and effectiveness of topical fluorides and how they should be properly used. Much of the blame for this situation, however, should be placed on the shoulders of the public health dentists, rather than on the practicing dentist. I am afraid that we in the public health field, with a basic responsibility for implementing the widespread utilization of preventive measures, have not been as forthright in disseminating information about topical fluorides as we should have been.

Lastly, the promotion of community water fluoridation in recent years—a measure which has many assets as a mass caries preventive—has occupied much of the time and interest of the dental profession and, in fact, has over-shadowed topical fluoride treatments. While this statement may appear to be paradoxical, the very existence of water fluoridation has been an important factor in retarding the utilization of topical fluoride therapy for the groups of children who cannot benefit from the water fluoridation program. Water fluoridation has provided us with a wonderful opportunity to rationalize less than adequate use of topical fluorides.

These several factors—relatively high cost of the service; restrictive licensure laws which do not permit auxiliary personnel to apply the solution; individual variability and susceptibility to caries; the intangible nature of the service as compared to other dental services; a less than forthright position on topical fluoride therapy by the public health dentist; and the many assets of community water fluoridation—have combined in various ways to keep private dentists and

public agencies from using topical fluorides as much as they might have.

If the potential which topical fluorides have for caries control is to be realized broadly, there are three steps which might be taken to extend the preventive measure to a larger group of children.

1) We shall have to delegate the application of topical fluorides to auxiliary personnel. In order to accomplish this objective, there will have to be a marked change in the dental profession's attitude toward the performance of certain chairside functions. Generally speaking, the dentist has been extremely reluctant to use other hands than his own to provide dental service, yet there is no reason why he cannot delegate many of the procedures associated with dental care. Specifically, there is no good reason why a dental hygienist, or even a lesser-trained person, cannot apply topical fluorides equally as well as a dentist. Yet this concept is a contributory factor which actually deprives many children of the benefits of topical fluoride therapy.

If we are to accomplish the broad goal of using auxiliary personnel for topical fluoride treatments, we shall have to take action on several fronts. The change in the attitude of the dental profession about delegating the treatment to other personnel will come about only after much examination into and discussion of the whole process of dental practice, and, I suspect, will be an evolutionary rather than a revolutionary change. Specifically, and as an item for immediate action, we can seek revision of practice acts in order to authorize auxiliary personnel to carry out such treatments, legally and actually.

In addition, if this goal of using other personnel is to be realized, there will have to be more auxiliary persons trained to provide the treatment. We shall have to seek the establishment of additional facilities to train dental hygienists and other auxiliary personnel.

2) We shall have to improve further the technique and shorten the length of time involved in treatment. By means of study and development, the procedure was reduced to 4 applications and refined to include a multiple chair procedure. The work of the Indiana group in developing the technique requiring one application of stannous fluoride looks like a further step in that direction. Much additional research and study can and should be done, however, to simplify and streamline the method of application and to make it more effective. The reduction of time required for treatment alone, with its associated economic advantages, would do much to insure greater utilization of topical fluorides in private dental offices and in public programs.

3) We shall have to promote and support organized community programs for bringing topical fluoride treatments to the nation's children. Although there always will be a place for topical fluoride therapy in the private practice of dentistry, and every dentist has an obligation to use this preventive for the protection of his own patients, the reasonable and logical way to bring the benefits of topical fluorides to any sizeable number of children is by means of some kind of community program. There should be an organized program of treatment, on a public, pay or part-pay basis, using auxiliary personnel, group methods and community facilities, so the preventive will be available to all children not now on fluoridated water.

However, I do not believe that there should be an organized topical fluoride

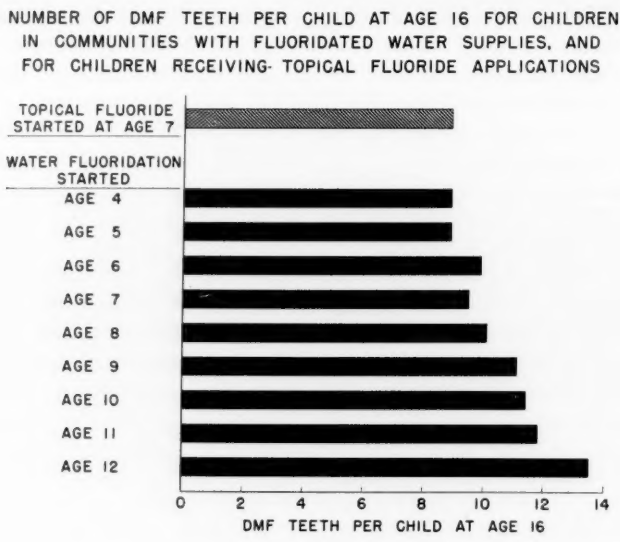

Figure II

treatment program in a community once it has started to fluoridate its water supply. No directly comparable data are available for use in determining whether simultaneous use of fluoridated water and topical fluoride applications would result in a lower attack rate than if fluoridated water alone were used over a period of years.[28-29] We can get some clues by comparing data obtained from separate studies concerned with the number of new DMF teeth observed for specific ages following topical fluoride applications,[13] and the number of new DMF teeth following fluoridation of a community water supply.[30-32]

In Figure II are plotted the number of DMF permanent teeth per child that may be expected at age 16 in children who have been given topical fluoride applications beginning at age 7, and the number of DMF teeth observed, also at age 16, in children who were four through twelve years of age at the time fluoridation was instituted in Grand Rapids, Michigan.

If one assumes that there will be a 40 per cent reduction in new DMF teeth as a result of the topical fluoride applications started at age 7 and continued as recommended, a total of about 9 DMF permanent teeth would have developed in the topically treated children by the time they have reached age 16. This estimated level of caries attack for topically treated 16-year olds is shown by the first bar. The remaining bars in the figure show the number of DMF teeth observed in the Grand Rapids children at age 16 who were ages four through twelve at the time water fluoridation began. It is evident that those children who were 6 years of age and older at the time fluoridation began have more DMF teeth by the time they reach age 16 than the estimated level for individuals who received topical fluoride applications. Those children who were less than 6 years of age when fluoridation began

have about the same level of DMF teeth. This comparison suggests that in the presence of water fluoridation topical fluoride therapy might provide some additional protection for children who were age 6 or older at the time fluoridation began and supports in general the proposal made several years ago when this question first arose.[33]

However, the difference in the number of DMF teeth between the topically treated child and those children who were less than nine years of age at the time fluoridation began, for instance, is so small as to raise serious question about the desirability of using public funds to supplement the benefits of water fluoridation with topical fluoride treatments. The possibility that topical fluoride treatment might provide additional protection to those chldren nine years of age and above is greater, of course, but in view of the shortage of personnel available to provide treatment and its relative expense, I do not believe continuing topical fluoride programs of an organized nature are warranted in those communities already fluoridating their water supply. The preventive effects of water fluoridation in the first year or two are quite immediate and are great enough so that publicly employed personnel might use their time more profitably in educational, restorative and other kinds of community dental health activities.

I do not mean to imply that topical fluoride treatments are contraindicated for patients in private dental offices after community water fluoridation has commenced. However, from the data contained in Figure II it would appear that topical fluorides would be of no value to patients who were under six years of age at the time fluoridation began. Treatment might be justified for private patients who were between the ages 6 through 11 at the time the water supply was supplemented. For those children 12 years of age and above at the time water fluoridation began, topical fluoride treatments would seem clearly indicated. The decision would have to be made by each dentist, however, on the basis of a variety of economic and physiological factors unique to the individual patient.

Summary

I am delighted that Dr. Bibby has asked us to take another look at the need for, and the potential of, topical fluoride therapy. Such an evaluation is long overdue. There has been confusion and doubt about the place of topical fluoride treatments today, and they have not been used as extensively as they should have been.

If topical fluoride treatments are to be used effectively to reach more of the 29,000,000 children not covered by water fluoridation (not even considering those who could benefit to some limited extent by topical fluoride treatments during the early years of community water fluoridation programs) we shall have to take action in the following ways:

1. Allow auxiliary personnel legally and actually to apply solutions, and provide for the necessary training of the additional personnel required for more extensive use.

2. Develop simpler and more effective techniques of application.

3. Develop more community programs to bring the benefits of topical fluoride therapy to large groups of children on an economical and practical group basis.

BIBLIOGRAPHY

1. Status of Controlled Fluoridation in the United States—1945-1957. Pub. Health Rep. 73:634-636, July 1958.
2. Bibby, B. G., A new approach to caries prophylaxis. Tufts Dent. Outlook 15:4-8, May 1942.

3. BIBBY, B. G., Preliminary report on use of sodium fluoride applications in caries prophylaxis. J. Dent. Res. 21:314, June 1942.
4. BIBBY, B. G., The effect of sodium fluoride applications on dental caries. J. Dent. Res. 22:207, June 1943.
5. BRUDEVOLD, F., et al., Uptake of tin and fluoride by intact enamel. Am. Dent. A. J. 53:159-164, Aug. 1956.
6. KLINKENBERG, E. and BIBBY, B. G., Effect of topical application of fluorides on dental caries in young adults. J. Dent. Res. 29:4-8, Feb. 1950.
7. KNUTSON, J. W. and ARMSTRONG, W. D., The effect of topically applied sodium fluoride on dental caries experience. I. Report of findings for the first study year. Pub. Health Rep. 58:1701, 1943.
8. KNUTSON, J. W. and ARMSTRONG, W. D., Ibid. II. Report of findings for the second study year. Pub. Health Rep. 60:1085, 1945.
9. KNUTSON, J. W. and ARMSTRONG, W. D., Ibid. III. Report of findings for the third study year. Pub. Health Rep. 61:1683, 1946.
10. KNUTSON, J. W., ARMSTRONG, W. D. and FELDMAN, F. M., The effect of topically applied sodium fluoride on dental caries experience. IV. Report of findings with two, four, and six applications. Pub. Health Rep. 62:425, 1947.
11. GALAGAN, D. J. and KNUTSON, J. W., The effect of topically applied fluorides on dental caries experience. V. Report of findings with two, four, and six applications of sodium fluoride and of lead fluoride. Pub. Health Rep. 62:1477, 1947.
12. GALAGAN, D. J. and KNUTSON, J. W., Effect of topically applied fluoride on dental caries experience. VI. Experiments with sodium fluoride and calcium chloride . . . widely spaced applications . . . use of different solution concentrations. Pub. Health Rep. 63:1215, 1948.
13. KNUTSON, J. W. and SCHOLZ, G. C., The effect of topically applied fluorides on dental caries experience. VII. Consolidated findings for four study groups. Pub. Health Rep. 64:1403, 1949.
14. NEVITT, GEORGE A., WITTER, DANIEL H. and BOWMAN, WINSTON D., The effect of topically applied sodium fluoride and stannous fluoride on dental caries experience. In Press. Pub. Health Reports.
15. MUHLER, J. C., BOYD, T. M. and VAN HUYSEN, G., Effect of fluorides and other compounds on the solubility of enamel, dentin, and tricalciumphosphate in dilute acids. J. D. Res. 29:182, 1950.
16. MUHLER, J. C. and DAY, H. G., Effects of stannous fluoride, stannous chloride, and sodium fluoride on the incidence of dental lesions in rats fed a caries-producing diet. J. Am. Dent. Assoc. 41:528, 1950.
17. RADIKE, A. W. and MUHLER, J. C., Incidence of dental caries in hamsters receiving two different water-soluble fluorides at low concentrations. J. D. Res. 32:807, 1953.
18. MUHLER, J. C., NEBERGALL, W. H. and DAY, H. G., Studies on stannous fluoride and other fluorides in relation to the solubility of enamel in acid and the prevention of experimental dental caries. J. Dent. Res. 33:33, 1954.
19. MUHLER, J. C., RADIKE, A. W., NEBERGALL, W. H. and DAY, H. G., A comparison between the anticariogenic effects of dentifrices containing stannous fluoride and sodium fluoride. J. Am. Dent. Assoc. 51:556, 1955.
20. MUHLER, J. C., The effect of vanadium pentoxide, fluorides, and tin compounds on the dental caries experience in rats. J. D. Res. 36:787, 1957.
21. HOWELL, C. L., GISH, C. W., SMILEY, R. D. and MUHLER, J. C., Effect of topically applied stannous fluoride on dental caries experience in children. J. Am. Dent. Assoc. 50:14, 1955.
22. GISH, C. W., HOWELL, C. L. and MUHLER, J. C., A new approach to the topical application of fluorides for the reduction of dental caries in children. J. D. Res. 36:784-786 (Oct.) 1957.
23. HOWELL, C. L. and MUHLER, J. C., Effect of topically applied stannous chloro-fluoride on the dental caries experience in children. II. Results two years after treatment. J. Am. Dent. Assoc. 55:493-495 (Oct.) 1957.
24. 1950 survey of the dental profession. Bureau of Economic Research and Statistics. Am. Dent Assoc., Chicago, Ill. 1951.
25. Social Security Administration, Children's Bureau. Maternal and Child Health Services. Reports from States for 1956 (unpublished data).
26. KILANDER, H. F., National survey of dental aspects of school health services. J. Am. Dent. Assoc. 51:159-167 (Aug.) 1955.
27. Facts about States—1957. Bureau of Economic Research and Statistics. Am. Dent. Assoc., Chicago, Ill.
28. DOWNS, R. A. and PELTON, W. J., Effect of topically applied fluorides in dental caries experience on children residing in fluoride areas. J. Colorado State Dent. Assoc. 29:7-10 (Dec.) 1950.
29. GALAGAN, D. J. and VERMILLION, J. R., Effect of topical fluorides on teeth matured on fluoride-bearing water. Pub. Health Rep. 70:1114-1115 (Nov.) 1955.
30. ARNOLD, F. A., DEAN, H. T., JOY, P. and KNUTSON, J. W., Effect of fluoridated public water supplies on dental caries prevalence. Tenth year of the Grand Rapids-Muskegon Study. Pub. Health Rep. 71:652-658 (July) 1956.
31. ARNOLD, F. A., Grand Rapids fluoridation study—Results pertaining to the eleventh year of fluoridation. Am. J. of Pub. Health 47:539-545 (May) 1957.
32. Results of the twelth year of re-examination in Grand Rapids. Unpublished data in file of Division of Dental Public Health, PHS.
33. KNUTSON, J. W., Topical fluorides in today's dental caries prevention program. Penn. Dent. J. 18:129-137 (May) 1951.

PRESENT STATUS OF TOPICAL FLUORIDE THERAPY

JOSEPH C. MUHLER, D.D.S., Ph.D.*

THE partial control of human dental caries by communal fluoridation is now well established. It has been repeatedly demonstrated by independent investigators throughout the world that the fortification of a fluoride-deficient water supply results in a significant reduction in dental caries in both children and adults who have consumed such water during the entire period that their permanent teeth were calcifying. As a result many workers are prone to feel that communal fluoridation is the complete solution to our dental caries problem. However, only a few seconds of consideration will reveal that if one believes that communal fluoridation is the only acceptable method of using fluorides, the potential benefits of fluoridation (now we refer to the use of flourides both in the communal water supply and when used topically) that we can bring to millions of additional people is being seriously handicapped. The need for the dental profession to increase their use of topical fluoride therapy is based on four essential inherent deficiencies of the communal fluoridation program: (1) at the present rate of increase of cities fluoridating their communal water supplies, it will be many years before a significantly greater proportion of our people will receive fluoride by this method; (2) communal fluoridation as now practiced will never benefit children who use a private water supply; (3) all people who are over 6-8 years of age at the present time and who have not lived in an area where the communal water or their individual water supply contains optimal fluoride, will not benefit significantly from this means of fluoride therapy; and (4) communal fluoridation is not 100 per cent effective. These four items, taken collectively, strongly suggest the need for the increased use of topical fluoride therapy in those instances where the population does not receive the now established benefits of communal fluoridation. In fact, limited evidence suggests that a single application of stannous fluoride applied once every six months to children who have lived all their lives in a fluoride area is associated with a significant caries reduction. If such studies can be confirmed by independent investigators, the combined effectiveness of both communal and topical fluoridation may show additive anticariogenic effects. This type of thinking has served as the stimulus for the Indiana group to continue their investigations concerning the effectiveness of topical fluorides. The experimental results of many previous workers were reviewed, and a procession of scholarly clinical studies led the way to the presently advocated "Single Application Technique."

The idea to "space" the fluoride treatments over several weeks, or even months in some cases, is not new. It was originally investigated in order to improve the anticariogenic effectiveness of the topical treatment, but it must also have been reasoned by those testing such techniques that such a procedure may increase the attractiveness of the fluoride technique so the dental profession would use it more frequently. Bibby's pioneer-

* Dept. of Biochemistry, Indiana University Medical Center, Indianapolis 7, Indiana.

ing work in this area is particularly noteworthy, and much of the present day successful use of the single stannous fluoride treatment has resulted from the basic studies designed and carried out by Bibby and his associates. This pertains both to the "spacing" of the fluoride treatment as well as to those investigations designed to specifically improve the anticariogenic effectiveness of sodium fluoride, such as the use of wetting agent, hydrogen peroxide, and the like.

In 1942 Bibby[1] demonstrated that the use of 3 treatments of a 0.1 per cent solution of sodium fluoride spaced 4 months apart resulted in a 46 per cent reduction in the incidence of dental caries in children at the end of one year, and a 33 per cent reduction at the end of two years. Shortly afterwards, Knutson and Armstrong evaluated the effectiveness of a series of 7 to 15 treatments of a 2 per cent solution of sodium fluoride given within a 2 month period for their ability to reduce the incidence of dental caries in 7-15-year-old children. Their conclusions were that 4 applications provided as much of an anticariogenic benefit as 5 or more treatments.[2] In 1947 Galagan and Knutson studied the effect of 2, 4 or 6 applications of a 2 per cent solution of sodium fluoride, all of which were given within a three-week period. Their clinical evidence suggested that 4 applications resulted in the optimal conditions for sodium fluoride since 6 applications resulted in no greater anticariogenic effect.[3] In 1948 these same workers reported on the effect of 2, 3 or 4 applications of a 2 per cent sodium fluoride solution when applied at time intervals varying between 2 weeks to 6 months. The results of this clinical study showed that the most optimal anticariogenic results were obtained when 4 applications were given within a 2 week period.[4]

These studies taken collectively would seem to predict that when sodium fluoride is used the greatest anticariogenic effectiveness would be obtained if 4 applications were given within a 2 week period. While a considerable number of studies certainly point to this conclusion, it cannot be definitely stated that these are in reality the most optimal conditions. Some evidence does suggest that a single application of sodium fluoride given every 4 to 6 months will significantly reduce dental caries.[5-7] It is true that in these latter studies the evidence was obtained on very small numbers of children, but the results were directionally the same in all of the studies. Sufficient importance can be attributed to such studies so that the recommendation can be made suggesting that more attention be given to the single application technique. Moreover, since the data which suggest optimal conditions for sodium fluoride are not applicable to stannous fluoride, additional clinical studies using this fluoride are required. This is the main stimulating factor which prompted the Indiana group to determine those experimental conditions both *in vitro* and subsequently *in vivo* which would indicate the optimal conditions for stannous fluoride when used with a single application technique.

Clinical Studies Using Various Fluorides

Five separate clinical tests have been conducted in children in our attempt to determine the most optimal clinical conditions for the single stannous fluoride technique. In all of these studies very

strict adherence to recognized methods of eliminating bias were followed.

The first clinical study was conducted in Bloomington, Indiana, and consisted of approximately 1,400 children, ages 6 to 15 years. Approximately 250 children received an aqueous unbuffered 2 per cent solution of sodium fluoride. A control group of 277 children received no treatment except a prophylaxis and clinical examination. In the group receiving sodium fluoride and in 450 children receiving stannous fluoride, the solutions were applied and allowed to dry for 4 minutes, according to the technique of topical application described by Knutson.[8] This technique consists of a thorough dental prophylaxis followed immediately by the first topical fluoride application. Within a period not exceeding 10 days, three additional topical treatments are given, although only the first is preceded by a prophylaxis. For the remaining one-half of the stannous fluoride group, the solution was applied so as to keep the teeth moist throughout the four-minute treatment time. The solutions were applied to all the teeth in the mouth with cotton applicators.

Of the original children who participated in the test initially, 1,053 were available for re-examination at the end of two years. Table 1 shows the caries increment over the two year period in terms of the average number of new carious surfaces per person and in terms of the percentage reduction in incidence of new caries based on the control group. The most complete estimate of the effects of the three fluoride treatments lies in the last column labeled "total DMF surfaces." These numbers were obtained

TABLE 1

SUMMARY OF CARIES FINDINGS AFTER 2 YEARS IN CHILDREN RECEIVING EITHER STANNOUS FLUORIDE OR SODIUM FLUORIDE WHEN TOPICALLY APPLIED.[9]

Average caries increment per person for two year period

Group	Subjects	Aver. DMF Teeth	Average DMF Surfaces: In prev. caries-free teeth	In prev. DF teeth	Prox. surfaces	Occ. surfaces	Bucc. and lingual surfaces	Total DMF surfaces
Control	139	2.84	3.83	.69	2.19	2.24	.09	4.52
A*	92	2.17	2.38	.50	1.70	.98	.21	2.88
B†	194	0.48	1.84	.02	1.59	.38	–.11	1.86
C‡	195	1.11	1.99	–.43§	1.31	.44	–.19	1.56

Percentage difference or reduction in increase of new caries compared to those of control group

Group	DMF Teeth	In prev. caries-free teeth	In prev. DF teeth	Prox. surfaces	Occ. surfaces	Total DMF surfaces
A	23.6	37.9	27.5	22.4	56.2	26.3
B	83.1	52.0	97.1	27.4	83.0	58.8
C	60.9	48.0	100.0	40.2	80.4	65.5

* Sodium fluoride by cotton applicator.

† Stannous fluoride by cotton applicator.

‡ Stannous fluoride by spray, continuously applied.

§ This negative number was taken as zero for computation of percentage reduction.

from counts of all the carious surfaces in all the teeth. In terms of this index, the sodium fluoride group experienced 36.3 per cent less new decay during the two year period than did the control group. The two stannous fluoride groups experienced 58.8 per cent and 65.5 per cent less new decay than did the control group. All of these percentage reductions are significant, as "t" tests indicated probabilities of less than 0.01 that the difference was due to chance alone. The apparent superiority of the stannous fluoride continuously applied by spray over sodium fluoride applied with a cotton applicator has a probability of being due to chance of 0.02, and that of stannous fluoride applied with an applicator over sodium fluoride has a probability of 0.06.

Since a tin-containing fluoride was more effective than sodium fluoride in the first clinical test, it became of interest to see if more effective compounds than stannous fluoride could be found. Several hundred compounds were tested in the laboratory, and from these two seemed to be promising enough to warrant clinical investigations. These were stannous chlorofluoride and potassium fluorostannite. Stannous chlorofluoride and sodium fluoride were applied to the erupted teeth of approximately 800 children, ages 6 to 15 years, in Gas City, Indiana. One-half of the children were treated with a 1 per cent aqueous unbuffered solution of sodium fluoride, and approximately the same number received a 4 per cent unbuffered stannous chlorofluoride solution. Both fluorides were applied to the teeth by cotton applicators using the technique described by Knutson.[8] The concentrations of the fluorides used in this study were chosen so that the fluoride levels would be identical. All the solutions were prepared fresh each morning and noon from oxygen-free water. Approximately 1 year after the initial fluoride applications, the children were re-examined.

After one year the incidence of new caries in previously noncarious teeth treated with stannous chlorofluoride was reduced by about 85 per cent *more* than the reduction in the children who received the sodium fluoride treatment.[10] Because one of the most important aspects of topical fluoride therapy is the duration of effectiveness, the effectiveness of stannous chlorofluoride after a two-year period has greater interest.[11] This is shown in Table 2. These data indicate that the stannous chlorofluoride was 33 per cent more effective after two years than was sodium fluoride as evidenced by the DMF tooth index. This difference is highly significant.

The second promising agent, potas-

TABLE 2

COMPARISON BETWEEN TOPICALLY APPLIED STANNOUS CHLOROFLUORIDE AND SODIUM FLUORIDE ON THE DENTAL CARIES REDUCTION IN CHILDREN TWO YEARS AFTER THE INITIAL SERIES OF TREATMENTS.[11]

Group	*No. of Subjects*	*Av. DMF Teeth*	*Total DMF Surfaces*
Stannous chlorofluoride	357	1.22	2.74
Sodium fluoride	363	1.82	3.58
Standard error of difference		1.81	3.30
Probability		0.0003	0.0003
Per cent reduction in caries rate		33	23

TABLE 3

A COMPARISON OF CARIES INCREMENTS AFTER 3 YEARS IN TWO GROUPS OF CHILDREN, ONE OF WHICH RECEIVED FOUR APPLICATIONS OF A 4 PER CENT SOLUTION OF POTASSIUM FLUOROSTANNITE AND THE OTHER FOUR APPLICATIONS OF DISTILLED WATER.

Group	*No. of Subjects*	*Mean Increments*	
		DMFT	DMFS
Control	304	2.14	4.58
$KSnF_3$	253	1.27	2.58
Per cent reduction		40.6	43.7
p		0.00001	0.00001

sium fluorostannite, was tested in Brazil, Indiana. This compound seemed to have the advantage of increased stability in solution. Rat studies also have indicated that its activity in reducing dental caries is similar to that of stannous fluoride.[12] A total of 894 children, aged 6 through 15 years, were initially treated in this study program. The children were divided into 9 susceptibility classes on the basis of previous dental caries experience and dental age. Within each susceptibility class they were then assigned to either Group A (distilled water) or Group B ($KSnF_3$) by a randomizing process which maintained equal numbers of subjects in each of the 2 groups. Group A received a thorough prophylaxis followed by a series of 4 applications of distilled water within a two week period. Group B received a prophylaxis and 4 applications of a 4 per cent solution of potassium fluorostannite. The technic of application was identical with that described by Knutson[8] except that the teeth were kept moist with the distilled water or fluoride throughout each 4-minute treatment. Since this solution was considered more stable than stannous fluoride, fresh solutions were prepared only as needed for mass application. This was usually once or twice a day.

After approximately 10 months, the children were re-examined by the same dentist using the same equipment and procedures. At the time of the second examination, 801 of the original 894 children were available for re-examination. The dental caries increment in terms of DMFT was 1.21 for the control group and 0.56 for the potassium fluorostannite group, representing a 53.7 per cent reduction in the dental caries experience in the experimental group. When the total DMFS index was used for comparative purposes, the potassium fluorostannite group showed a 39.2 per cent reduction in comparison to the control group.[13]

Again because of the importance of the duration of effectiveness the protective effect must be emphasized. The results at the end of three years are shown in Table 3. A highly significant reduction in dental caries was found when either the DMFT or DMFS indices were used for comparative purposes. These data are of real importance since they demonstrate a highly significant caries reduction three years following the initial treatment series. These data clearly show not only a higher degree of effectiveness of the potassium fluorostannite over sodium fluoride, but also a longer duration of effectiveness.

Topical Applications on Primary Teeth

The literature reveals that little attention has been paid to the inhibitory value of the topical application of fluorides on primary teeth. Cheyne[14] applied a 0.05 per cent solution of potassium fluoride to the primary teeth of 27 children 4½ to 6 years of age. After one year, he reported a 50 per cent reduction in carious lesions when compared to a control group of 19 children. However, since the number of subjects was so small, little reliability can be placed upon the reported degree of effectiveness. Jordan[15] in a more extensive study which involved over 900 children, studied the caries inhibiting effect resulting from the application of different numbers of sodium fluoride treatments on primary and permanent teeth. The results following 1, 2, or 3 applications were 4.9, 14.5, and 40 per cent less caries respectively in the primary dentition. The inhibitory effect seemed to have a tendency to be more pronounced for primary than permanent teeth in the group receiving 2 or 3 applications. Ast[16] applied a 2 per cent sodium fluoride solution to one-half the mouth of 260 children and reported a 22 per cent overall caries inhibition as compared to the untreated teeth. Wittich[17] studied 40 children, using the half-mouth technique, and also noted a 22 per cent reduction in the incidence of caries with sodium fluoride. Sundvall-Hagland[18] recently reported a study in which 209 children with a median age of 2 years 8 months were observed at 1, 2, and 3 year intervals. Of these children, 107 received 4 applications of a 2 per cent sodium fluoride solution. A caries inhibition of 19 per cent for the first year, 14 per cent for the second, and 9 per cent for the third year was reported. The teeth which were carious at the time of the initial fluoride treatments were unaffected by the topical sodium fluoride applications.

McDonald and Muhler[19] compared the effectiveness of stannous fluoride and sodium fluoride for their ability to reduce the dental caries experience of the primary teeth. A total of 300 children who came to the Indiana University Pedodontic Clinic were selected at random for participation in this study program. Since the effectiveness of topical fluoride application to the primary teeth was the purpose of this study, children were selected who would retain their primary teeth for at least a 2 year period. Radiographs were taken for all the subjects in the group at each examination period.

Group 1 received 4 applications of a 4 per cent aqueous solution of stannous fluoride. The stannous fluoride solution was prepared fresh for each application. Group 2 received 4 applications of a 2 per cent aqueous solution of sodium fluoride. Each group received a thorough prophylaxis immediately prior to the first fluoride application. The second, third, and fourth fluoride applications were completed within a two week period and were not preceded by a dental prophylaxis. The teeth to be topically treated were isolated with cotton rolls, carefully dried with warm air, and the fluoride solution applied continuously by means of cotton applicators for a 4-minute period. Group 3 received only a prophylaxis and served as the control group.

Of the 300 children initially treated, a total of 227 were available for examination at the end of one year. The stan-

nous fluoride group was composed of 86 children with a medium age of 6.16 years. The sodium fluoride group contained 76 children with a median age of 6.10 years. The control group had 65 children with a median age of 7.13 years.

Table 4 shows the mean caries increment for the one-year period in terms of the average number of new DMF primary teeth, and the total new DMF surfaces on previously sound and previously carious teeth as well as the percentage reduction as compared to the control group. The stannous fluoride group experienced a 57 per cent reduction in new carious teeth and a 37 per cent reduction in surfaces when compared to the control group. Both of these reductions are statistically significant.

Number of Topical Applications

The presently advocated procedure for topical application of sodium fluoride[8] requires 4 visits to the dental office once every 3 years in order to obtain the maximum benefit. As a result many dentists have not adopted the use of topical applications as a routine office procedure. In order to develop a procedure which would be simplified, it was decided to compare the anticariogenic effectiveness of a single application of stannous fluoride with that of the conventional four applications of sodium fluoride. A total of 554 second grade children from Montgomery County, Indiana, were used in this study. Only second grade children were used because this program was designed so as to continue throughout a five-year period by continuing the treatment each year and by adding new second graders as they enter school. The children were divided into 9 susceptibility classes on the basis of previous dental caries experience and dental age. Within each susceptibility class they were then assigned to Group I (sodium fluoride) or Group II (stannous fluoride) on the basis of estimated caries expectancy.[20]

Group I received an aqueous unbuffered 2 per cent solution of sodium fluoride, the first application of which was given immediately following a thorough prophylaxis by the whole mouth technique described by Knutson.[8] The second, third, and fourth treatments were given 2 to 7 days apart. Group II received a prophylaxis and a single application of an aqueous 8 per cent unbuffered solution of stannous fluoride. The technique of application of the solutions was the same except that the teeth treated with stannous fluoride were kept moist with the solution throughout the 4-minute treatment time.

TABLE 4

MEAN CARIES INCREMENT IN THE PRIMARY TEETH OF CHILDREN RECEIVING EITHER A SERIES OF TOPICAL APPLICATIONS OF SODIUM FLUORIDE OR STANNOUS FLUORIDE DURING A ONE YEAR STUDY PERIOD.[19]

Group	*Subjects*	*Mean Total New DMF Teeth*	*% Reduction*	*Mean Total New DMF Surfaces (on previously sound and carious teeth)*	*% Reduction*
Stannous Fluoride	86	0.33	57	1.79	37
Sodium Fluoride	76	0.61	21	2.50	12
Control	65	0.77	..	2.84	..

TABLE 5

THE EFFECTIVENESS OF ONE APPLICATION OF AN 8 PER CENT SOLUTION OF SnF_2 AS COMPARED WITH FOUR APPLICATIONS OF A 2 PER CENT NaF SOLUTION.[21]

	NaF	*SnF_2*	*"Superiority" (%)*
Number of subjects	242	247	
Number of sound permanent teeth at start	8.3	8.1	
DMFS at start	2.9	3.0	
DMFT increment	0.76	0.60	21 (p = 0.08)
DMFS increment	1.25	0.93	26 (p = 0.025)
Proximal	0.16	0.14	12
Occlusal	0.70	0.57	19
Buccal-lingual	0.39	0.22	44

After 8 months, 2 years, and 3 years, the children were re-examined by the same dentist using the same equipment and procedures. The examiner did not know what treatment each child received or what caries experience was previously recorded.

In Table 5 the dental caries increments in terms of the DMFS and DMFT indices are shown, as well as the components of the DMFS. The average increment in DMFT for the sodium fluoride group was 0.76 while that for the stannous fluoride group was 0.60, or a difference of 21 per cent. Thus, 1 application of the solution of stannous fluoride was 21 per cent more effective in preventing new noncarious teeth from becoming carious than 4 applications of a 2 per cent solution of sodium fluoride. This difference is significant at the 0.08 level of confidence.

Based on the DMFS index, there was a difference of 26 per cent in favor of stannous fluoride. This index represents the total new carious surfaces which occurred during the test, and is probably the best estimate of the effectiveness of the two fluorides. The difference of 26 per cent between the 2 groups is significant at the 0.025 level of confidence.

The results of this clinical study indicate a significant advantage of 1 application of an 8 per cent solution of stannous fluoride over the conventional series of 4 applications of sodium fluoride. Even if the ability of the 1 application of stannous fluoride to prevent dental caries were only the same, the reduction in the number of treatments from 4 to 1 would be a worthwhile achievement.

The results at the end of three years are shown in Table 6 and indicate the findings for children in Group I who have now received three single stannous fluoride applications one year apart and those children who have received one series of four applications of sodium fluoride. Group II children have been similarly treated, but were started two years ago. Group III children were started one year ago. In Group I, the dental caries increments in terms of DMFS and DMFT indices indicate a significant superiority of a single application of stannous fluoride at the end of one year as shown in Table 6. At the end of two years this same group has maintained its significant superiority for the children receiving the stannous fluoride. After three years, there is a 35 per cent superiority for the children receiving the stannous fluoride as compared to

those receiving the sodium fluoride when the DMFT index is used, and a 35 per cent superiority when the DMFS index is used. All of these reductions are significant as indicated in Table 6. It is of interest to note that not only has the single stannous fluoride application technique maintained its significant superiority over sodium fluoride during a three-year study program, but its effectiveness seems to increase when the three year data are compared with those obtained at the end of one year. This is of real significance, since one of the major objectives of a successful topical treatment program is one which maintains the anticariogenic effectiveness over an extended period of time.

If this reduction in caries continues for even longer periods, the numerical decrease in caries prevalence will be highly significant in terms of the total teeth saved from caries, and a significant contribution to preventive dentistry will be available for the general practitioner. This technique is of particular importance, since the dentist most frequently must see the young patient at least once a year, and at this appointment a single application of stannous fluoride can materially add to the management of his caries control program by means of a simple, quick, and clinically effective technique.

As a result of such encouraging findings, Indiana University was prompted to study the effectiveness of a single application of a 10 per cent solution of SnF_2 on adults.

Approximately 500 Indiana University freshmen 17 to 38 years of age, were divided according to previous dental caries experience into 2 groups. Group I received a single application of distilled water, and Group II a single application of a 10 per cent unbuffered aqueous solution of stannous fluoride. Both groups received their respective treatments immediately following a thorough prophylaxis. The stannous fluoride solution was prepared and used immediately according to techniques previously described.

TABLE 6

A COMPARISON OF THE EFFECTIVENESS AT THE END OF 3 YEARS OF A SINGLE APPLICATION PER YEAR OF AN 8 PER CENT SOLUTION OF STANNOUS FLUORIDE TO A SERIES OF FOUR APPLICATIONS OF SODIUM FLUORIDE ONCE EVERY THREE YEARS.

Group	*Time of Examination*	*Agent*	*No. of Subjects*	*DMF Teeth*		*DMF Surfaces*	
				INCREMENT	% REDUCTION	INCREMENT	% REDUCTION
I	1 year	NaF	242	0.76		1.25	
		SnF_2	247	0.60	21 (p = .08)*	0.93	26 (p = .025)
	2 year	NaF	222	1.08		1.94	
		SnF_2	226	0.73	32 (p = .004)	1.53	21 (p = .04)
	3 year	NaF	220	1.48		2.68	
		SnF_2	196	0.96	35 (p = .001)	1.73	35 (p = .002)
II	1 year	NaF	237	0.58		1.19	
		SnF_2	230	0.24	59 (p = .0007)	0.52	56 (p = .000_)
	2 year	NaF	235	0.98		1.88	
		SnF_2	222	0.53	46 (p = .001)	0.81	57 (p = .0001)
III	1 year	NaF	226	0.84		1.33	
		SnF_2	224	0.58	31 (p = .001)	0.86	35 (p = .001)

* Calculated on the basis of the "t" test.

TABLE 7

THE EFFECT OF A SINGLE TOPICAL APPLICATION OF A 10 PER CENT UNBUFFERED AQUEOUS SOLUTION OF STANNOUS FLUORIDE ON CARIES REDUCTION IN ADULTS AFTER A ONE-YEAR PERIOD.

	Group		*Dental Caries Reduction*
	CONTROL	SnF_2	(%)
Number of subjects	207	228	
DMFT increment	0.95	0.72	24 (p = .04)*
DMFS increment	2.98	2.50	16 (p = .08)
Proximals	2.03	1.50	26
Occlusals	0.64	0.57	11
Buccal-lingual	0.31	0.42	–35

* Probability based upon the "t" test.

Each adult received a 7-film bite-wing examination and clinical dental caries examination at the initial visit and again after a 12 month period. Similar precautions were taken in order to eliminate bias both in the examinations and recordings of the data as were taken in previous studies.

The dental caries data from the water and stannous fluoride treated groups are seen in Table 7. The single application of stannous fluoride reduced the caries increment by 24 and 16 per cent when evaluated by the DMFT and DMFS indices, respectively.

Topical Applications in Users of Fluoridated Water

The question asked of us by most dentists is whether or not the single application technique is effective to any degree in children who have received the now-established benefits of communal fluoridation. This question seemed so important that a study was designed in order to study this problem. Sodium fluoride has been found to be ineffective in reducing dental caries in children living in a fluoride area. Galagan[22] studied the effect of topical fluorides on the teeth of 350 children, 7 to 16 years of age, which matured in an area containing natural fluorides in the water. A series of topical applications of a 2 per cent solution of sodium fluoride resulted in a 9 per cent reduction in the dental caries incidence.

Indianapolis, Indiana, which artificially fluoridates its communal water supply, was chosen for the experimental city. At the time this clinical program began (which was three years ago), Indianapolis had been fluoridating for a period of six years. While perhaps it would have been better to select an area in which all of the children's teeth tested in this study would have received fluoridated water during the period that the teeth were calcifying, personnel and monetary considerations prohibited such a useful criterion. However, the use of this city is justified since this topical study will continue for at least five years. Such a period will provide sufficient data on 6, 7, 8, 9, and 10-year-old children whose teeth have developed in the presence of optimal fluoride to draw accurate conclusions.

A total of 600 children were selected for this study from the parochial and public school systems surrounding the Indiana University Dental School. Only

children who have resided all their lives in Indianapolis were chosen for study. All of the children were divided into one of two groups on the basis of past caries experience. By such a procedure excellent balance between the two groups, as evaluated by either the number of sound permanent teeth present, the DMFT index, or the DMFS index, was shown. Group I received a single application of an 8 per cent solution of SnF_2 every six months, and Group II received a single application of distilled water every six months. The fluoride or water applications were given by the senior dental hygienists at the Indiana University School of Dentistry. Clinical and radiograph examinations were made at six month intervals.

The data for six months and the preliminary one year data are presented in Table 8. These data show the number of subjects available for re-examination at the various periods. Please note that the entire group have not finished the 12 month period, and as a result one should view these data as only preliminary trends. At the end of six months there is a significant caries reduction as evaluated by either the DMFT or DMFS indices. While the per cent of reduction values are not dramatic, they do show a significant beneficial effect of the single application technique in a fluoride area. The preliminary data at the end of 12 months similarly seem to suggest that the treatment effect will be maintained.

Of obvious concern to all of us is the effect of the single application of stannous fluoride in those children whose teeth have calcified in the presence of optimal fluoride, or in the 6, 7, and 8 year old group. These data, namely the per cent reductions (in terms of DMFS) as a function of age of the children at the start of the test are shown in Table 9.

While no definite conclusions are possible at this early point of the study, and while it would not be prudent to speculate on these data until independent corroboration is available, certain conclusions do seem justifiable:

(1) The use of a highly concentrated stannous fluoride solution applied once every 6 months, following a thorough dental prophylaxis, is associated with a significant reduction in dental caries in 6-15 year old children whose teeth have calcified in an optimal fluoride area. (2) Preliminary analysis of the data shows no relationship between the anticariogenic effectiveness of the topical stannous fluoride application and the length of

TABLE 8

SINGLE TOPICAL APPLICATION OF AN 8 PER CENT SOLUTION OF STANNOUS FLUORIDE IN CHILDREN LIVING IN A FLUORIDE AREA.

	6 Months		*12 Months*	
	CONTROL	SnF_2	CONTROL	SnF_2
Number of subjects	225	224	160	162
DMFT increment	0.88	0.59	1.48	0.96
Per cent reduction		32.9		35.13
"p"		0.05		0.005
DMFS increment	1.57	1.04	2.64	1.90
Per cent reduction		33.7		28.03
"p"		0.01		0.022

TABLE 9

REDUCTION IN DENTAL CARIES IN CHILDREN RESIDING IN A FLUORIDE AREA FOLLOWING THE TOPICAL APPLICATION OF A SINGLE APPLICATION OF AN 8 PER CENT STANNOUS FLUORIDE SOLUTION AS A FUNCTION OF AGE AT THE TIME OF THE INITIAL TREATMENT.

	6 Months		*12 Months*	
Age	NO.	% REDUCTION*	NO.	% REDUCTION*
6	23	3	18	35
7	57	34	41	35
8	81	34	59	42
9	70	43	57	0
10	62	17	39	9
11	41	0	22	–50
12	35	44	20	37
13	36	–10	17	32
14	20	87	5	..

* Based on DMFS.

time the children lived in a fluoride area.

Conclusions

The results of many different human clinical tests conducted by numerous different independent investigators have repeatedly shown that a 2 per cent solution of sodium fluoride applied four times within a 2 week period is associated with a significant reduction in dental caries in children, provided the first topical application is preceded by a dental prophylaxis. However, due to the expedience of time both by the patient and the dentist, this procedure of topical fluoridation is not used as much as it should be. Since stannous fluoride appears to be more effective than sodium fluoride as an anticariogenic agent, its effectiveness was compared to sodium fluoride. Numerous human clinical tests have all indicated that when the stannous ion is present in a fluoride compound, a greater anticariogenic effect results than when sodium fluoride is used. Since clinical evidence has suggested that the effectiveness of sodium fluoride may be as great with "spaced" applications as with the four-application technique, stannous fluoride was evaluated using a single application technique. The results of such a clinical study clearly demonstrate that a single application of an 8 per cent solution of stannous fluoride applied once a year is significantly more effective than 4 applications of sodium fluoride applied once each three years. Further clinical studies with stannous fluoride using the single application technique have suggested that topical stannous fluoride treatments are effective in children whose teeth have developed in the presence of fluorides, and in limited studies a reduction in dental caries in adults has been reported.

These studies, taken collectively, strongly suggest that the dental profession should give serious consideration to the use of topical fluoride therapy as an adjunct to their preventive dentistry procedures. The single stannous fluoride technique seems to most optimally fit into the office routine, and in addition, has given good assurance of producing a significant anticariogenic effect.

Dentistry should not accept such studies as reported here as a complete answer to the dental caries problem. The pioneering work of Bibby and his associates, and the more recent studies of Muhler and his coworkers have clearly demonstrated that more effective fluorides can be found. It is now the object of dental research to find an even more effective compound than stannous fluoride for topical fluoride therapy.

BIBLIOGRAPHY

1. Bibby, B. G., A New Approach to Caries Prophylaxis. A preliminary report on the rise of fluoride preparations. Tufts Dental Outlook 15:4, 1942 (see also J.A.D.A. 31:228, 1944; J.A.D.A. 34:26, 1947).
2. Knutson, J. W., and Armstrong, W. D., The Effect of Topically Applied Sodium Fluoride on Dental Caries Experience. Pub. Health Rept. 58:1701, 1943 (see also Pub. Health Rept. 60:-1085, 1945 and 61:1683, 1946).
3. Galagan, D. J., and Knutson, J. W., The Effect of Topically Applied Fluorides on Dental Caries Experience; Report of Findings With Two, Four, and Six Applications of Sodium Fluoride and of Lead Fluoride. Pub. Health Rept. 62:-1477, 1947.
4. Galagan, D. J., and Knutson, J. W., Effect of Topically Applied Fluoride on Dental Caries Experience. IV. Experiments with sodium fluoride and calcium chloride; widely spaced applications; use of different solution concentrations. Pub. Health Rept. 63:1215, 1948.
5. Bibby, B. G., Use of Fluorine in the Prevention of Dental Caries. I. Rationale and approach. J.A.D.A. 31:228, 1944.
6. Fulton, J. T., and Tracy, E. T., Use of Topical Fluorine on School Age Children and Its Effect on Dental Caries. Connecticut Health Bull. 60:-55, 1946.
7. Syrrist, A., En klinisk studie av effekten av lokale behandlinger med natriu-mfluorid som kariesprofylaktisk middel. Odont. Tidsskr. 57:-511, 1949.
8. Knutson, J. W., Sodium Fluoride Solution: technic for application to the teeth. J.A.D.A. 36:-37, Jan. 1948.
9. Howell, C. L., Gish, C.W., Smiley, R. D., and Muhler, J. C., Effect of Topical'y Applied Stannous Fluoride on Dental Caries Experience in Children. J.A.D.A. 50:14, Jan. 1955.
10. Howell, C. L., and Muhler, J. C., Effect of Topically Applied Stannous Chlorofluoride in the Dental Caries Experience in Children. Science 120:316, 1954.
11. Howell, C. L., and Muhler, J. C., Effect of Topically Applied Stannous Chlorofluoride on the Dental Caries Experience in Children. II. Results two years following initial treatment. J.A.D.A. 55:493, 1957.
12. Muhler, J. C., The Effect of Vanadium Pentoxide, Fluorides, and Tin Compounds on the Dental Caries Experience in Rats. J. D. Res. 36:787, 1957.
13. Gish, C. W., Muhler, J. C., and Howell, C. L., The Effect of Topically Applied Potassium Fluorostannite in the Dental Caries Experience in Children. J. D. Res. 36:780, 1957.
14. Cheyne, V. D., Human Dental Caries and Topically Applied Fluorine: a preliminary report. J.A.D.A. 29:804, 1942.
15. Jordan, W. A., Wood, O. B., Allison, J. A., and Irwin, V. D., The Effects of Various Numbers of Topical Applications of Sodium Fluoride. J.A.D.A. 33:1385, 1946.
16. Ast, D. B., Sodium Fluoride Dental Caries Prophylaxis. N. Y. S. Dent. J. 16:441, 1950.
17. Wittich, H. C., Effect of Topical Application of Sodium Fluoride on Deciduous Teeth. North West Dent. 29:113, 1950.
18. Sundvall-Hagland, Irene, Sodium Fluoride Application to the Deciduous Dentition. A clinical study. Acta. Odont. Scandinavica 13: 5-131 suppl., 1955.
19. McDonald, R. E., and Muhler, J. C., The Superiority of Topical Application of Stannous Fluoride on Primary Teeth. J. Dent. for Child. 24:84, 1957.
20. Muhler, J. C., Radike, A. W., Nebergall, W. H., and Day, H. G., The Effect of a Stannous Fluoride-Containing Dentifrice on Caries Reduction in Children. J. D. Res. 33:606, 1954.
21. Gish, C. W., Howell, C. L., and Muhler, J. C., A New Approach to the Topical Application of Fluorides for the Reduction of Dental Caries in Children. J. D. Res. 36:784, 1957.
22. Galagan, D. J., and Vermillion, J. R., Effect of Topical Fluorides on Teeth Matured on Fluoride-Bearing Water. Pub. Health Rept. 70:-1114, 1955.

ACTION OF TOPICALLY APPLIED FLUORIDE

FINN BRUDEVOLD, D.D.S.

THERE is no doubt that topical applications of fluoride must affect the tooth itself and in some way reinforce it and thus render it more caries resistant. This reinforcement must obviously be related to deposition of fluoride in the tooth structure. In the case of stannous fluoride, the effect must be related to a deposition of fluoride, and, in addition, a deposition of tin. This discussion will, therefore, center on what is known about the acquisition by tooth structure of fluoride and tin from solutions which have been used in topical applications.

Let us first briefly consider some of the chemistry involved when fluoride solutions come in contact with tooth structure. Usually 1 or 2 per cent fluoride solutions are used in topical applications. At such high concentrations of fluoride the inorganic structure in the tooth which comes in touch with the fluoride solution will actually decompose. Both the enamel and the dentin consist of thousands and thousands of calcium phosphate crystals made of hydroxy apatite. When exposed to strong fluoride solutions they will break down and be changed to calcium fluoride and sodium phosphate. This is shown in the following reaction:

Strong F soln. → decomposition of crystal with formation of CaF_2.

$$Ca_{10}(PO_4)_6(OH)_2 + 20NaF \rightarrow 10CaF_2 + 6Na_3PO_4 + 2NaOH$$

The calcium fluoride will precipitate as a very fine powder on the tooth surface, and the other products, the sodium phosphate and sodium hydroxide, will dissolve and wash away. Part of the calcium fluoride will wash away too, but whatever is left will slowly dissolve and participate in another reaction:

Weak F soln. → Change hydroxyapatite to fluorapatite. F exchanges with OH.

$$Ca_{10}(PO_4)_6(OH)_2 + CaF_2 \rightarrow Ca_{10}(PO_4)_6F_2 + Ca(OH)_2$$

This is a completely different reaction in which crystal structure remains intact, but hydroxyl groups will be replaced by fluoride. This second reaction will take place only at low concentrations of fluoride, and calcium fluoride which is slightly soluble, will provide such a low fluoride solution when it is precipitated on the tooth's surface. The fluorapatite formed by this second reaction is quite insoluble compared to the original hydroxy apatite, and, therefore represents a more resistant material.

This second reaction of fluoride with tooth structure is essentially a surface reaction. There is hardly any penetration of fluoride into the bulk of the enamel, and little penetration into dentin. Therefore, if we wish to measure the increase in enamel of fluoride after fluoride treatment, only the outermost part of the treated enamel must be examined. It is like assessing the amount of paint on a piece of lumber. On a percentage weight basis the amount of paint is insignificant, but if we shave off and examine the outer layer then the paint becomes measurable. Such a "shaving" procedure has been used by a few investigators in measuring fluoride uptake by intact enamel. The outer part of the enamel was ground off and subjected to chemical analysis. The results are summarized in Table 1.

The first study cited on the table was done in Canada, the second and third in Sweden, and the fourth was a joint project of the Eastman Clinic in Stockholm and our own Eastman Dental Dis-

TABLE 1

F UPTAKE BY THE OUTER ENAMEL FROM TOPICAL APPLICATIONS OF NaF

Agent	*Treatments*			*F ppm*	
	PERIOD MINS.	NO.	INTERVAL	EXPERIMENTAL	CONTROL
NaF 2%	10	8	1 week	950	340*
NaF 2%	5	4	1 week	620	430**
NaF 4%	10	4	1 week	1100	570**
NaF 2%	4	4	3 days	165	110***

* Dog.
** Human permanent.
*** Human primary.

pensary. In all the fluoride-exposed teeth the concentration of fluoride is increased compared to the untreated controls. The increase is most impressive in the first study which was done on dogs. The teeth were treated eight times, ten minutes each time. With this much more prolonged treatment than is used in topical applications, the fluoride concentration in the outermost enamel was increased from 340 ppm to 950 ppm. Although appreciable amounts of fluoride were taken up under these conditions, the treated enamel is far from fluoride saturated. Complete saturation of the enamel would have brought the fluoride concentration up to 40,000 ppm. The next two studies were done on teeth which were going to be extracted for orthodontic reasons. In one of these studies four five-minute treatments were given. This treatment approximates that used in clinical studies and it will be noticed that it caused the fluoride in the enamel to increase from 430 to 620 ppm. When a 4 per cent sodium fluoride solution was used and treatment period increased to ten minutes, the four treatments gave a much greater fluoride increase, from 570 ppm to 1100 ppm. The fourth study is of particular interest because the teeth used were extracted after they had been observed for three years during a clinical study and the caries reducing effect of the fluoride applications had been assessed. These teeth showed only a very slight increment of fluoride (55 ppm) resulting from the topical applications.

From these investigations we can conclude that only minute amounts of fluoride are deposited in the enamel as a result of topical applications. But this slight increase is apparently capable of rendering the tooth more caries resistant. Now, why are only small amounts of fluoride acquired by enamel, and how is it possible that such small increments in fluoride content can be effective? An answer to these questions is found when the enamel is magnified some 20,000 times with an electron microscope so that we can see the individual crystals with which the fluoride reacts. When this is done enamel crystals from human enamel show as needle-like tablets up to roughly one one thousandth of a millimeter long with much smaller dimensions for width and thickness. The rat crystals are much longer than the human. In intact enamel the crystals are closely packed together, but exceedingly small spaces do exist between the crystals. These spaces which are greater in

young than in old enamel are filled in part with organic structure and in part with water.

It has been found that the water adjacent to the crystal is attracted to the crystal surface by electrostatic forces which are so powerful that it may actually be considered part of the crystal. This tightly bound water layer, or hydration shell, may be regarded as one part of the crystal, the surface of the crystal as another part, and the interior of the crystal as a third portion. These parts do not react in the same way.

When fluoride is introduced into the environment of the crystal it will react first with the hydration shell, then with the crystal surface and finally with the interior of the crystal. These are three entirely different types of reactions which occur at different rates. Since the reactions between radioactive phosphorus (P^{32}) and apatite crystals have been carefully investigated they can be used to indicate what happens during removal of fluorine from the solution to the crystal. It is important that the first reaction which involves the hydration shell is very rapid. The next reaction, between the fluoride in the hydration shell and the crystal surface, is much slower but still fairly rapid. In experiments the reaction with the surface was completed in about six hours. The third reaction, the migration of fluoride into the interior of the crystal, is exceedingly slow. For fluoride saturation of the crystal to take place this third reaction would have to go to completion. We have analyzed hundreds of teeth and many bone specimens, and have not yet found a single sample which was saturated with fluoride, e.g. in which this third phase, the reaction with the interior of the crystal, has gone to completion. Even teeth which have been buried in fluoride-containing soil for thousands of years are found to be fluoride unsaturated. Obviously then, when teeth are exposed to fluoride in the drinking water or in topical applications, we are dealing essentially with two first types of reactions, one with the hydration shell of the crystals and a subsequent one with the crystal surface. The latter reaction with the crystal surface is probably the more important one, because it fixes the fluoride firmly to the crystal surface and produces the well known solubility reducing effect.

The type of reaction we can expect from fluoride treatment then, is some kind of a coating reaction in which the crystal surface is saturated with fluoride ions. As already mentioned, this coating effect is obtained only on the crystals located in the outer part of the enamel. The penetration of fluoride into the bulk of the enamel is indeed very slight, probably because the crystals are packed so closely together that hydration is insufficient for ionic transfer. We can now see why increase in the concentration of fluoride in fluoride treated enamel is so slight. The amount of fluoride needed to provide a coating of the crystals at the enamel surface is infinitestimal and penetration of fluoride into the enamel crystals is virtually non-existent. This coating of the crystals is, however, capable of providing the crystal with a stronger surface resistance, much in the same way as a coat of paint works.

That the fluoride is concentrated in the outer layers of the enamel is shown by fluoride analyses of enamel grindings from untreated teeth collected in Buffalo. Progressing from the outside in, the successive layers contained 528, 232, 150, 96 and 33 ppm of fluoride.

TABLE 2

FLUORIDE AND TIN CONCENTRATION IN EXTERNAL ENAMEL AFTER EXPOSURE TO 1 PER CENT SODIUM FLUORIDE, 1.86 PER CENT STANNOUS FLUORIDE AND 4.12 PER CENT STANNOUS CHLOROFLUORIDE

Test Agent	*pH*	*Per Cent in Test Solution*		*Enamel* TIN PPM LAYER		*Enamel* FLUORIDE PPM LAYER	
		TIN	FLUORIDE	1	2	1	2
Sodium Fluoride	5.6	0.0	0.452	25	5.6	1,440	561
Stannous Fluoride	2.9	1.41	0.452	600	250	1,200	580
Stannous Chlorofluoride .	1.6	2.82	0.452	640	300	1,031	570
Control	..	0.0	0.0	15	10	924	400

In what seems to be the only study of fluoride distribution after making topical applications a 34 per cent reduction of caries in primary teeth was accompanied after one year by a 30 per cent increase of fluoride in the outermost layer of enamel of the treated teeth. After four very careful applications of 2 per cent sodium fluoride the fluoride content of the two outer layers was 160 and 50 ppm.

What happens when teeth are treated with stannous fluoride? Table 2 shows the uptake of fluoride and tin from 1 per cent solution of sodium fluoride and solutions of stannous fluoride and stannous chlorofluoride containing the same concentration of fluoride as the sodium fluoride solution. The teeth were exposed for 20 minutes and then bathed in 100 cc. of fresh saliva for one hour. Thereafter they were washed repeatedly and shaken for one half hour in 100 cc. of distilled water. It will be noticed that quite a bit of tin was picked up by the teeth exposed to stannous fluoride and stannous chlorofluoride. The tin penetrated some distance into the tooth because not only the outermost enamel but also the second layer contained reasonably high concentrations of tin. It is interesting that most fluoride was picked up by the sodium fluoride solution followed by stannous fluoride and stannous chlorofluoride in that order. The acidity of the stannous fluoride solutions, pH 2.9 for stannous fluoride and 1.6 for stannous chlorofluoride should be noticed.

The tin and fluoride uptake from .02 per cent sodium fluoride and equivalent concentrations of stannous fluoride and a stannous fluoride containing toothpaste (Crest) are shown in Table 3. With these weaker solutions, the tin and fluoride uptake is less than that shown in the previous Table but the pattern is the same. Most fluoride was taken up by enamel from the sodium fluoride solution and less from stannous fluoride solution and the stannous fluoride toothpaste. It should also be noted that while appreciable amounts of tin were taken up from the stannous fluoride solution, no tin was taken up from the toothpaste. However, in later tests some tin was actually acquired from the toothpaste. Our findings for both fluoride and tin have recently been confirmed by the manufacturers, who also showed that most of the tin is taken up in the first few minutes of exposure.

The tin apparently forms insoluble tin phosphates which deposit in the enamel. However, phosphates are not

TABLE 3

FLUORIDE AND TIN CONCENTRATION IN EXTERNAL ENAMEL AFTER EXPOSURE TO .0214 PER CENT SODIUM FLUORIDE, .04 PER CENT STANNOUS FLUORIDE AND A TOOTHPASTE SLURRY CONTAINING .04 PER CENT STANNOUS FLUORIDE

Test Agent	*pH*	*Per Cent in Test Solution*		*Enamel* TIN PPM LAYER		*Enamel* FLUORIDE PPM LAYER	
		TIN	FLUORIDE	1	2	1	2
Sodium Fluoride	6.0	0.0	0.0098	22	4.3	968	508
Stannous Fluoride	3.7	0.0305	0.0098	150	21.0	883	432
Toothpaste Slurry	6.0	0.0305	0.0098	24	6.3	850	467
Control	..	0.0	0.0	20	22.0	777	445

the only compound which can form. We have shown that in the presence of sulphides the stannous ion will form insoluble sulphide which is yellow to grey-black in color. Therefore, in using stannous fluoride one should be aware of the possibility of tooth discoloration.

Finally it should be pointed out that the caries reducing effect of topical applications may be particularly important in the earliest stages of caries initiation. We have seen that relatively small amounts of fluoride and tin are deposited in intact enamel. Studies with radioactive fluorine (F^{19}) have shown that up to five times more fluoride is deposited in white spots and incipient caries lesions than in adjacent normal enamel. This suggests that topical applications may reduce caries more by retarding or arresting caries already in progress than by strengthening the intact enamel. This point is difficult to prove because the initial stage of dental caries represents only slight changes in the microstructure of the enamel which are virtually undetectable by available procedures of clinical examination. Clinically, caries is recognized as a cavitation in the tooth or a shadow in a standard x-ray film, but Grenz Ray studies indicate that even the smallest detectable cavity is preceded by development of microscopic porosities of the surface and more advanced decalcification of subsurface enamel. Such incipient caries lesion which the clinical examiner is apt to miss and record as "caries free" will readily acquire fluoride, tin and other metallic ions, and may well be significantly reinforced by topically applied agents.

In conclusion it can be stated that although progress has been made towards understanding the mode of action of caries-inhibiting agents such as fluorides and tin there is still much to be found out on the subject. It is likely that more detailed knowledge in this area may lead to even more effective methods of adding to the caries resistance of the enamel than those which we now know.

Eastman Dental Dispensary
Rochester 3, N. Y.

Dentin Dimensions of Primary Teeth*

SUMTER S. ARNIM, D.D.S., PH.D.,† AND MILLARD P. DOYLE, D.D.S., M.S.‡

INTRODUCTION

THIS paper records a series of measurements made on the dentin of the crowns of primary teeth. The purpose of the research was to determine the shortest distance from the dentino-enamel junction to the pulp at various levels in the crown. The dentino-enamel junction was chosen as a base line from which the measurements were made because dentin is formed rhythmically and is deposited in regular increments.[1, 2] As a result of this biologic circumstance, distances from the walls of the pulp chamber to the nearest points on the dentino-enamel junction are remarkably constant at a given level.

The data collected demonstrate so little variation in the measurements from tooth to tooth in groups of homologous teeth, i.e. maxillary first molars, that the observations made are useful clinically for planning cavity preparations.[3] When this basic information is applied correctly in operative dentistry the dental surgeon excises enamel and dentin of primary teeth in such a manner that the pulp is safeguarded, dentin is conserved and the spatial attributes of the completed cavity meet best the mechanical requirements for a long lasting restoration.

In other words, it is practical to use the dentino-enamel junction as a base line from which cavity preparations in dentin may be mapped and measured. By so doing the operator can plan precisely the direction and depth of the cuts in relation to the proximity of the dental pulp and surrounding enamel. Consequently, the operation can be designed within the spatial limitations of the tissues involved so that a maximal amount of healthy dentin is preserved to conserve the pulp and strengthen the tooth while a minimal amount of tooth substance is excised to meet the mechanical requisites for adequate retention of the completed restorations. Operations so planned and performed are physiologically acceptable, biomechanically sound and professionally excellent.

HISTORICAL NOTES

Measurements of distances from the dental pulp to specific anatomic landmarks that can be used easily by the operator for planning depth of cavity preparations are not easily found. The need for some guide, other than that of bitter experience, is felt frequently by all who operate on teeth. Wedelstadt[4, 5] was one of the first to define dimensional attributes of cavity preparations. He measured distances from the dental pulp to the tooth surface in extracted permanent teeth. He also measured the size of teeth and cavities in the mouth. Bronner[6] considered information concerning tooth dimensions a prerequisite for planning

* The data presented herein were collected, in part, while the authors were on the staff of the Dental School of the Medical College of Virginia. Grateful acknowledgment is made for the interest and support provided by the College and members of the staff. This research was supported, in part, by Public Health Service Research Grant D-200 and by the Procter and Gamble Research Grant.

† Sumter S. Arnim, Professor of Pathology, Director, Postgraduate School of Dentistry, The University of Texas Dental Branch.

‡ Millard P. Doyle, D.D.S., M.S., 816 Medical Arts Building, Norfolk, Virginia.

operative procedures and made a number of measurements from the pulp to various points on the enamel surface which he used as a basis for discussing engineering principles in relation to cavity preparation. Although data were not recorded on primary teeth his knowledge of the insufficiency of dentin for adequate retention of restorative materials is reflected in his contribution to Miller's text.[7] He also points out the great need for restoration of the complete contour of primary teeth to maintain equilibrium of the forces of occlusion during the developmental period and quotes Addelston[7] as favoring the Willett[8] inlay as the restoration of choice.

Kurer[9, 10] contributed data on the dimensional attributes of primary teeth and applied the information to clinical practice. He found pulpitis and periapical involvement more often after filling primary teeth than permanent. The disturbances were caused by the lack of dentin in the primary teeth. This led to his studies of enamel and dentin thickness in 125 molars. The teeth were sectioned in a mesiodistal direction. An average enamel and dentin thickness of 1.6 mm. was found with variables that indicated it is not safe to count on more than 1.4 mm. Amalgam restorations, placed within this limit of depth, gave such low values of resistance when tested by the Brinell ball pressure method that Kurer felt a more resistant material should be used. His work is important because it shows that good results are obtained with amalgam when sufficient dentin thickness with adequate cavity depth are available. It also explains why failures occur when the reverse is true. He recommended a technic that leads to a greater proportion of success by using inlays anchored with superficial grooves. This operation avoids the pulp, takes less time and keeps the child more comfortable.

Russman[11] studied the anatomy of the pulp chamber in the primary dentition and compared measurements made on radiograms with those taken from extracted teeth. He felt that roentgenograms of primary teeth could be utilized to estimate operating room in the molars even though there were some differences, statistically, between measurements made on the films and correspondingly on the extracted teeth.

Sweet[12] presented data obtained from drawings by Nuckolls giving measurements of the primary teeth from the pulp chamber to the tooth surface. He stated the data have been confirmed by exact measurements of roentgenograms and ground sections of extracted teeth. The dimensions recorded from the pulpal wall to the enamel surface were 1.8 mm. for the maxillary first, 1.6 mm. for the mandibular first and 2.3 for the second molars. It would seem from study of the drawings shown that plane of sectioning, level of measurement and variability in enamel thickness, especially in the gingival third of the crown may account for differences between these and Kurer's[9] figures. Sweet also said that the operator should cut no deeper than just beneath the dentino-enamel junction so that pulpal horns would be safeguarded.

Brown[13] stressed the importance of the dentino-enamel junction as a guide during cavity preparations for primary teeth. He suggests that cutting in dentin be restricted to a maximum depth of ½ mm. in dentin, measuring from the dentino-enamel junction toward the pulp.

It is interesting to note that variations in size of primary teeth[14, 15, 16] fall within

a range that allows for the prefabrication of steel crowns which fit reasonably well.[17] The general acceptance of these crowns is a good clinical demonstration of the applicability of knowledge of tooth morphology to restorative dentistry. This thought has been extended further by studies on cavity form, cutting instruments, and stress factors as related to cavity preparation and restoration.[18, 19, 20, 21, 22, 23] These studies provide much information concerning cavity forms in relation to the completed restoration. Further information is desirable as the spatial relations of the preparations within dentin are not given in detail. There is also lack of data concerning the thickness of dentin between the cavity floors and the dental pulp. When studies of this type are made using human teeth instead of models, and the exact amount of dentin remaining between the restoration and the pulp is known, and this information is coupled with that currently available concerning pulp conservation during cavity preparation,[24, 25] the practising dentist will have the necessary information to guide him to a biomechanically and physiologically satisfactory operation.

Methods, Preparation of Teeth for Measurement

The teeth used came from a large collection* preserved in ten per cent formalin on extraction. They were kept in the solution until they were prepared for measurement.

When this study was first begun the measurements were made by grinding the teeth in a horizontal plane parallel to the cervical line. As the parts of interest were exposed by repeated grinding, measurements were made. When the tooth was ground down to the cervical line the last measurements were taken and the roots were discarded. This system was so slow it was decided to demineralize the teeth in weak acid, dehydrate them in alcohol and clear them with xylol containing three per cent paraffin. The teeth became transparent and the pulp horns and chambers were easily seen. They also acquired a leathery consistency which made them easy to hold. As the acid had removed most of the mineral salts they were easily sectioned with a razor blade into very thin slices.

Dimensional changes that take place during demineralization and clearing were measured in 12 teeth before and after processing. It was known from previous studies[26] that changes would be minimal. The results of the control group tested revealed no change in the acid or during dehydration but about four per cent average linear shrinkage in the clearing solution.

As a further means of evaluating this variable and as a check on the numbers of teeth necessary in order to obtain reproducible data a relatively large number of primary mandibular second molars were sectioned by grinding, Table X. The results indicated that processing changes the dimensions negligibly and that a series of 25 teeth will provide data that are reproducible.

* The authors express their gratitude to Drs. H. C. Ballou, Virginia State Department of Public Health, E. A. Branch, Public Health Director for the State of North Carolina, John Oppie McCall, Guggenheim Dental Clinic and Isaac Schour, Dean, School of Dentistry, University of Illinois who collected many of the teeth used in the study and also to those colleagues and dental students who gave teeth and time for measuring.

The Measurements

Measurements were made with a Boley gauge which had the prongs filed to sharp points. Each measurement was recorded twice. All were made along the shortest line from the wall of the pulp chamber to the dentino-enamel junction. Every reading recorded was the shortest distance from the pulp to the dentinal surface under consideration. The figures recorded are for dentinal thickness only and they represent the least amount of dentin found in the location studied.

The measurements from the tips of the pulp horns to the respective tips of the dentinal cusps were obtained by subtraction. First the distance was measured from the dentinal cusp tip to the root apex, the cusp was then sliced away in thin slices and as soon as the tip of the pulp horn was exposed another measurement was made to the root apex. The difference between the two measurements represented the distance from the pulp horn to cusp tip.

Teeth that were not demineralized were first ground until the tip of the dentinal cusp was revealed. The measurements to the root apex were then made as before. Then the crown over the pulp horn was ground down bit by bit and the second measurement was made.

The mesio-distal and labio-lingual diameters always represent the greatest distance found for these dimensions at the cervical line of a given tooth. The parallel arms of the Boley gauge were held approximately perpendicular to the plane of the labial surface when mesio-distal diameters were recorded.

The height of the dentinal crown represents the distance between two parallel planes, each perpendicular to the long axis of the tooth, one passing through that point of the curve of the cervical line on the labial surface closest to the apex of the root, the other passing through that point on the dentinal cusp farthest away from the apex of the root.

Number and Nature of Teeth Used

The teeth examined were divided into maxillary and mandibular making ten groups. They were designated according to standard terminology, i.e. central incisors A, lateral incisors B, cuspids C, first molars D, and second molars E. Teeth from the right side were not separated from those on the left.

Measurements were recorded from 25 or more teeth in each group. Carious lesions and on rare occasions, attrition, destroyed the tooth substance to be measured in some teeth. When possible, additional teeth were added that had no carious lesions in order to make the data as complete as possible. Sometimes tips of pulp horns coincided with the roof of the pulp chamber and this reduced the number of readings in this category. As might be expected the widest variations occurred in measurements of tips of pulp horns to cusp tips as secondary dentin or attrition often played a role in this area. The greatest lack of measurements occurred in the zones most frequently affected by dental caries, but the dimensions in these zones recorded from teeth with no lesions were in close accord with other readings around the pulp chamber at this level. This was especially true of the least distances found. All dimensions recorded are of sound dentin.

As a general rule large or small teeth, attrited teeth, teeth with little or lots of root resorption and those with or without perceptible secondary dentin all provided measurements within a comparatively small range.

Measurements were made from a total of 358 teeth and approximately 7,500 readings were taken. The data were analysed statistically for all teeth and the standard deviation as well as the standard error of the mean was calculated for the two groups of mandibular second molars, Table X.

The largest and smallest dimensions found are recorded in each table. This was done to provide the practitioner with knowledge of the minimal amount of dentin he might expect to encounter in a given location in any of the teeth studied. It is this minimal amount that determines the range of safety for depth of cut in dentin.

The Figures

The figures I to X are drawings of dissected teeth and illustrate the places where the measurements were made, representative anatomic characteristics and the appearance of demineralized sections in comparison to ground sections. They also summarize the data collected on each group of teeth, least measurements found are printed within the tooth outline and average distances are seen outside.

TABLE I

MAXILLARY CENTRAL PRIMARY INCISOR, $\underline{A}$

Where Measurements Were Made	*Number of Measurements Taken*	*Mean* MM.	*Average Deviation* MM.	*Range, mm.* MIN.	MAX.
Mesio-distal diameter at cervix	26	4.20	0.32	3.3	5.0
Labio-lingual diameter at cervix	26	3.97	0.27	3.1	4.6
Height of dentinal crown from cervix	26	5.47	0.63	3.9	7.2
Mesial pulp horn to incisal	25	2.31	0.44	1.4	3.8
Mesial pulp horn to mesial	25	1.20	0.17	1.0	1.8
Mesial pulp horn to labial	25	1.10	0.17	0.8	1.5
Mesial pulp horn to lingual	25	1.18	0.22	0.7	1.9
Distal pulp horn to incisal	25	2.37	0.38	1.8	3.8
Distal pulp horn to distal	25	1.23	0.19	0.9	1.7
Distal pulp horn to labial	25	1.08	0.16	0.7	1.6
Distal pulp horn to lingual	25	1.09	0.16	0.7	1.5
Pulp to labial at cervix	25	1.16	0.12	0.8	1.4
Pulp to lingual at cervix	25	1.35	0.24	0.9	1.9
Pulp to mesial at cervix	25	1.09	0.19	0.7	1.5
Pulp to distal at cervix	25	1.10	0.16	0.6	1.5

TABLE II

MANDIBULAR CENTRAL PRIMARY INCISOR, $\overline{A}$

Where Measurements Were Made	*Number of Measurements Taken*	*Mean* MM.	*Average Deviation* MM.	*Range, mm.* MIN.	MAX.
Mesio-distal diameter at cervix	25	2.61	0.15	2.0	3.0
Labio-lingual diameter at cervix	25	2.91	0.15	2.5	3.4
Height of dentinal crown from cervix	25	4.85	0.30	4.0	5.5
Pulp horn to incisal	25	2.25	0.33	1.2	3.2
Pulp horn to labial	25	1.01	0.15	0.7	1.5
Pulp horn to lingual	25	0.99	0.23	0.5	1.5
Pulp horn to distal	25	1.24	0.25	0.8	2.0
Pulp horn to mesial	25	0.96	0.11	0.8	1.3
Pulp to labial at cervix	25	0.95	0.06	0.8	1.2
Pulp to lingual at cervix	25	1.03	0.11	0.8	1.3
Pulp to mesial at cervix	25	0.91	0.08	0.7	1.3
Pulp to distal at cervix	25	0.93	0.07	0.8	1.1

TABLE III

MAXILLARY LATERAL PRIMARY INCISOR, $\underline{B}$

Where Measurements Were Made	*Number of Measurements Taken*	*Mean* MM.	*Average Deviation* MM.	*Range, mm.* MIN.	MAX.
Mesio-distal diameter at cervix	25	3.12	0.28	2.5	4.0
Labio-lingual diameter at cervix	25	3.79	0.33	2.2	4.5
Height of dentinal crown from cervix	25	5.65	0.41	4.6	6.9
Pulp horn to incisal	25	2.56	0.27	1.8	3.2
Pulp horn to labial	25	0.93	0.17	0.5	1.3
Pulp horn to lingual	25	1.10	0.28	0.8	1.7
Pulp horn to mesial	25	1.02	0.13	0.9	1.1
Pulp horn to distal	25	1.76	0.44	0.9	2.9
Pulp to labial at cervix	25	1.10	0.15	0.6	1.5
Pulp to lingual at cervix	25	1.32	0.29	0.8	2.3
Pulp to mesial at cervix	25	0.84	0.12	0.5	1.0
Pulp to distal at cervix	25	0.94	0.14	0.5	1.3

TABLE IV

MANDIBULAR LATERAL PRIMARY INCISOR, $\overline{B}$

Where Measurements Were Made	*Number of Measurements Taken*	*Mean* MM.	*Average Deviation* MM.	*Range, mm.* MIN.	MAX.
Mesio-distal diameter at cervix	25	2.81	0.13	2.4	3.2
Labio-lingual diameter at cervix	25	3.52	0.36	3.0	4.2
Height of dentinal crown from cervix	25	5.18	0.64	3.4	6.9
Pulp horn to incisal	25	2.62	0.46	1.6	4.0
Pulp horn to labial	25	1.09	0.14	0.8	1.4
Pulp horn to lingual	25	1.17	0.25	0.7	1.9
Pulp horn to mesial	25	0.98	0.11	0.8	1.4
Pulp horn to distal	25	1.39	0.33	0.9	2.3
Pulp to labial at cervix	24	1.11	0.12	0.8	1.4
Pulp to lingual at cervix	24	1.25	0.21	0.8	1.6
Pulp to mesial at cervix	24	0.84	0.09	0.5	1.1
Pulp to distal at cervix	24	0.96	0.09	0.7	1.2

TABLE V

MAXILLARY PRIMARY CUSPID, $\underline{C}$

Where Measurements Were Made	*Number of Measurements Taken*	*Mean* MM.	*Average Deviation* MM.	*Range, mm.* MIN.	MAX.
Mesio-distal diameter at cervix	24	4.87	0.25	4.0	5.3
Labio-lingual diameter at cervix	25	5.02	0.30	4.0	5.7
Height of dentinal crown from cervix	25	6.29	0.49	5.2	8.0
Pulp horn to cusp tip	25	3.21	0.34	2.5	4.4
Pulp horn to labial	25	1.73	0.24	1.1	2.2
Pulp horn to lingual	25	2.08	0.48	1.0	3.0
Pulp horn to mesial	25	1.95	0.33	1.4	2.9
Pulp horn to distal	25	2.17	0.36	1.4	2.8
Pulp to labial at cervix	25	1.70	0.16	1.2	2.0
Pulp to lingual at cervix	25	1.80	0.24	1.1	2.3
Pulp to mesial at cervix	25	1.26	0.17	1.0	1.7
Pulp to distal at cervix	25	1.28	0.15	1.0	1.7

TABLE VI

MANDIBULAR PRIMARY CUSPID, $\overline{c}$

Where Measurements Were Made	*Number of Measurements Taken*	*Mean* MM.	*Average Deviation* MM.	*Range, mm.* MIN.	MAX.
Mesio-distal diameter at cervix	25	4.22	0.26	3.8	4.7
Bucco-lingual diameter at cervix	24	4.60	0.31	4.1	5.2
Height of dentinal crown from cervix	25	6.25	0.50	4.2	7.4
Pulp horn to cusp tip	25	2.91	0.39	2.2	4.6
Pulp horn to labial	25	1.53	0.28	1.0	2.2
Pulp horn to lingual	25	1.60	0.36	1.0	2.5
Pulp horn to mesial	25	1.75	0.31	1.1	2.2
Pulp horn to distal	25	2.01	0.24	1.4	3.1
Pulp to labial at cervix	23	1.58	0.26	1.0	2.0
Pulp to lingual at cervix	25	1.70	0.26	1.0	2.2
Pulp to mesial at cervix	25	1.21	0.18	0.9	1.8
Pulp to distal at cervix	25	1.29	0.27	0.9	2.1

TABLE VII

MAXILLARY FIRST PRIMARY MOLAR, $\underline{D}$

Where Measurements Were Made	*Number of Measurements Taken*	*Mean* MM.	*Average Deviation* MM.	*Range, mm.* MIN.	MAX.
Mesio-distal diameter at cervix	26	4.72	0.32	4.0	5.6
Bucco-lingual diameter at cervix	28	6.59	0.42	5.5	8.0
Height of dentinal crown from cervix	28	5.05	0.29	4.1	5.9
Mesio-buccal pulp horn to cusp tip	24	1.83	0.30	0.8	2.5
Mesio-buccal pulp horn to buccal	24	1.57	0.32	1.0	2.2
Mesio-buccal pulp horn to mesial	21	1.54	0.42	0.9	2.6
Disto-buccal pulp horn to cusp tip	13	2.11	0.40	1.3	3.1
Disto-buccal pulp horn to buccal	14	1.34	0.31	0.8	1.8
Disto-buccal pulp horn to distal	5	1.31	0.15	1.1	1.5
Lingual pulp horn to cusp tip	20	2.05	0.62	1.2	3.8
Lingual pulp horn to mesial	21	1.49	0.35	1.0	2.8
Lingual pulp horn to distal	8	2.12	0.40	1.2	2.8
Lingual pulp horn to lingual	20	1.57	0.21	1.1	2.1
Pulp to mesial at cervix	24	0.99	0.15	0.5	1.4
Pulp to distal at cervix	7	1.16	0.19	0.9	1.5
Pulp to buccal at cervix	26	1.22	0.19	0.9	1.9
Pulp to lingual at cervix	26	1.39	0.21	1.0	2.0

The drawings shown in figures XI to XV exemplify the application of the basic knowledge presented to the clinical problem of restoration of a carious maxillary first primary molar with amalgam. The instruments shown are a 33½ inverted cone bur (.5 mm. diameter) and enamel hatchets 10-80-8-14, 10-95-8-14 R & L. These hand instruments are recommended in preference to burs for excising the mortise in dentin as they do not undermine the enamel and their width helps to keep the preparation shallow.

The drawings are made from dissected human teeth. A safety zone of dentin, .5 mm. or more thick covers the pulp in this instance. The completed restoration will have a thickness of 1.5 + mm. in the average case. Of course, if the least amount of dentin were present a cavity .5 mm. deep would expose the pulp. The difficulties encountered in excising sufficient dentin to provide adequate bulk to retain a strong amalgam and still leave enough dentin to safeguard the pulp are obvious. Studies of pulpal response to cavity preparation

indicate that at least .5 mm. of dentin is needed for safety.[24,25]

Discussion

Analysis of the foregoing data points to the desirability of restorations for primary teeth that rely upon an encircling design for retention and resistance.[3] When deep mortises are cut within the all too scanty dentinal substance the cavity preparation is often too close to the pulp for safety. As the average amount of dentin is usually about 1 mm. or more,

TABLE VIII

MANDIBULAR FIRST PRIMARY MOLAR, $\overline{D}$

Where Measurements Were Made	*Number of Measurements Taken*	*Mean* MM.	*Average Deviation* MM.	*Range, mm.* MIN.	MAX.
Mesio-distal diameter at cervix	26	5.89	0.36	4.8	7.0
Bucco-lingual diameter at cervix	26	4.66	0.31	3.8	6.6
Height of dentinal crown from cervix	27	5.44	0.26	4.9	6.6
Mesio-buccal pulp horn to cusp tip	28	2.14	0.34	1.4	3.1
Mesio-buccal pulp horn to buccal	28	1.42	0.37	0.8	2.7
Mesio-buccal pulp horn to mesial	27	1.62	0.29	0.7	2.2
Mesio-lingual pulp horn to cusp tip	28	2.44	0.29	1.4	4.2
Mesio-lingual pulp horn to mesial	28	1.54	0.29	0.9	2.8
Mesio-lingual pulp horn to lingual	28	1.29	0.17	0.9	1.8
Disto-buccal pulp horn to cusp tip	18	2.38	0.32	1.2	5.6
Disto-buccal pulp horn to buccal	17	1.32	0.22	1.0	2.0
Disto-buccal pulp horn to distal	9	1.35	0.29	1.0	2.1
Disto-lingual pulp horn to cusp tip	9	2.33	0.23	1.2	4.7
Disto-lingual pulp horn to distal	7	1.49	0.17	1.1	2.6
Disto-lingual pulp horn to lingual	9	1.09	0.12	0.9	1.7
Pulp to mesial at cervix	28	1.01	0.15	0.7	1.5
Pulp to distal at cervix	12	1.15	0.14	0.7	1.6
Pulp to buccal at cervix	28	1.20	0.24	0.7	1.9
Pulp to lingual at cervix	28	1.12	0.18	0.7	1.9

TABLE IX

MAXILLARY SECOND PRIMARY MOLAR, $\underline{E}$

Where Measurements Were Made	*Number of Measurements Taken*	*Mean* MM.	*Average Deviation* MM.	*Range, mm.* MIN.	MAX.
Mesio-distal diameter at cervix	31	5.63	0.41	4.8	7.6
Bucco-lingual diameter at cervix	31	8.29	0.55	7.0	10.1
Height of dentinal crown from cervix	31	5.73	0.37	4.2	6.8
Mesio-buccal pulp horn to cusp tip	10	2.90	0.40	1.8	3.8
Mesio-buccal pulp horn to buccal	11	2.29	0.32	1.1	2.7
Mesio-buccal pulp horn to mesial	7	1.76	0.15	1.3	2.5
Mesio-lingual pulp horn to cusp tip	14	2.90	0.28	2.2	4.2
Mesio-lingual pulp horn to mesial	15	2.18	0.25	1.5	3.9
Mesio-lingual pulp horn to lingual	18	2.44	0.36	1.0	3.8
Disto-buccal pulp horn to cusp tip	21	2.89	0.38	2.1	3.9
Disto-buccal pulp horn to buccal	23	2.01	0.26	1.3	2.7
Disto-buccal pulp horn to distal	23	1.88	0.25	1.4	2.5
Disto-lingual pulp horn to cusp tip	18	2.83	0.27	2.2	3.9
Disto-lingual pulp horn to distal	19	1.77	0.19	1.2	2.7
Disto-lingual pulp horn to lingual	19	2.05	0.21	1.2	2.8
Pulp to mesial at cervix	23	1.45	0.16	1.0	2.3
Pulp to distal at cervix	26	1.51	0.15	1.0	2.5
Pulp to buccal at cervix	26	1.67	0.17	1.1	2.5
Pulp to lingual at cervix	26	1.72	0.23	1.3	2.4

TABLE X

MANDIBULAR SECOND PRIMARY MOLAR, $\overline{E}$

Where Measurements Were Made	*Number of Measurements Taken**	*Mean* MM.*	*Average Deviation* MM.*	*Standard Error of the mean* MM.*	*Range, mm.* MIN.*	MAX.*
Mesio-distal diameter	*95*	*7.64*	*0.57*	*0.09*	*6.20*	*8.90*
at cervix	35	7.36	0.57	0.09	6.30	8.90
Bucco-lingual diameter	*94*	*7.01*	*0.74*	*0.13*	*5.20*	*8.50*
at cervix	34	6.91	0.74	0.13	5.25	8.50
Mesio-buccal pulp	*49*	*2.81*	*0.38*	*0.05*	*1.80*	*3.40*
horn to cusp tip	17	2.92	0.30	0.07	1.80	3.70
Mesio-buccal pulp	*67*	*2.43*	*0.35*	*0.04*	*1.55*	*3.75*
horn to buccal	21	2.47	0.34	0.07	1.50	3.80
Mesio-buccal pulp	*49*	*1.82*	*0.20*	*0.02*	*1.35*	*2.45*
horn to mesial	19	1.75	0.30	0.07	1.30	2.50
Mesio-lingual pulp	*61*	*3.15*	*0.39*	*0.05*	*2.20*	*4.15*
horn to cusp tip	22	3.17	0.37	0.08	2.20	4.20
Mesio-lingual pulp	*63*	*1.94*	*0.21*	*0.02*	*1.45*	*2.45*
horn to mesial	23	1.88	0.18	0.04	1.40	2.50
Mesio-lingual pulp	*70*	*1.93*	*0.23*	*0.02*	*1.25*	*2.45*
horn to lingual	25	1.89	0.21	0.04	1.20	2.50
Centro-buccal pulp	*86*	*3.02*	*0.23*	*0.05*	*1.60*	*3.80*
horn to cusp tip	25	3.11	0.23	0.05	1.60	3.80
Centro-buccal pulp	*83*	*2.37*	*0.26*	*0.05*	*1.55*	*3.45*
horn to buccal	23	2.34	0.26	0.05	1.50	3.50
Disto-buccal pulp	*61*	*3.08*	*0.43*	*0.05*	*2.00*	*3.80*
horn to cusp tip	16	3.06	0.41	0.10	2.00	3.80
Disto-buccal pulp	*65*	*2.45*	*0.44*	*0.06*	*1.65*	*3.45*
horn to buccal	17	2.68	0.43	0.10	1.60	3.50
Disto-buccal pulp	*62*	*1.83*	*0.16*	*0.02*	*1.40*	*2.20*
horn to distal	17	1.80	0.19	0.05	1.40	2.20
Disto-lingual pulp	*79*	*3.22*	*0.43*	*0.05*	*1.80*	*4.05*
horn to cusp tip	26	3.30	0.37	0.07	1.70	4.10
Disto-lingual pulp	*71*	*2.22*	*0.30*	*0.04*	*1.60*	*3.10*
horn to distal	21	2.30	0.28	0.06	1.60	3.10
Disto-lingual pulp	*80*	*1.99*	*0.26*	*0.05*	*1.35*	*2.65*
horn to lingual	26	1.97	0.26	0.05	1.30	2.70
Pulp to mesial at	*90*	*1.79*	*0.21*	*0.04*	*1.35*	*2.55*
cervical line	32	1.86	0.21	0.04	1.30	2.60
Pulp to distal at	*89*	*1.82*	*0.21*	*0.02*	*1.30*	*2.60*
cervical line	33	1.84	0.19	0.03	1.30	2.60
Pulp to buccal at	*94*	*1.99*	*0.29*	*0.05*	*1.65*	*2.80*
cervical line	33	2.00	0.29	0.05	1.30	2.80
Pulp to lingual at	*95*	*1.86*	*0.23*	*0.04*	*1.35*	*2.30*
cervical line	35	1.89	0.23	0.04	1.30	2.30

* Numerals in italics are data collected from teeth prepared by grinding.

we see why it is possible, as Kurer[9] says, to prepare many cavities without pulpal damage and subsequent failure. However the least distances found from the dental pulp to the dentino-enamel junction, reported herein, when coupled with the statistical evaluation of the data reveal that primary incisors and first molars especially have insufficient dentin to provide a safety zone of .5 mm. when the usual cavity preparation for amalgam is made. This condition accounts for those unexpected failures that are so embarrassing to the conscientious dentist and so agonizing to the patient.

In every case the distances from pulp horns to cusp tips were greater than to adjacent axial dentinal surfaces. As a rule there was more than 2.0 mm. of dentin occlusally and less than this laterally. This means that one finds somewhat more dentin occlusal to the pulp than

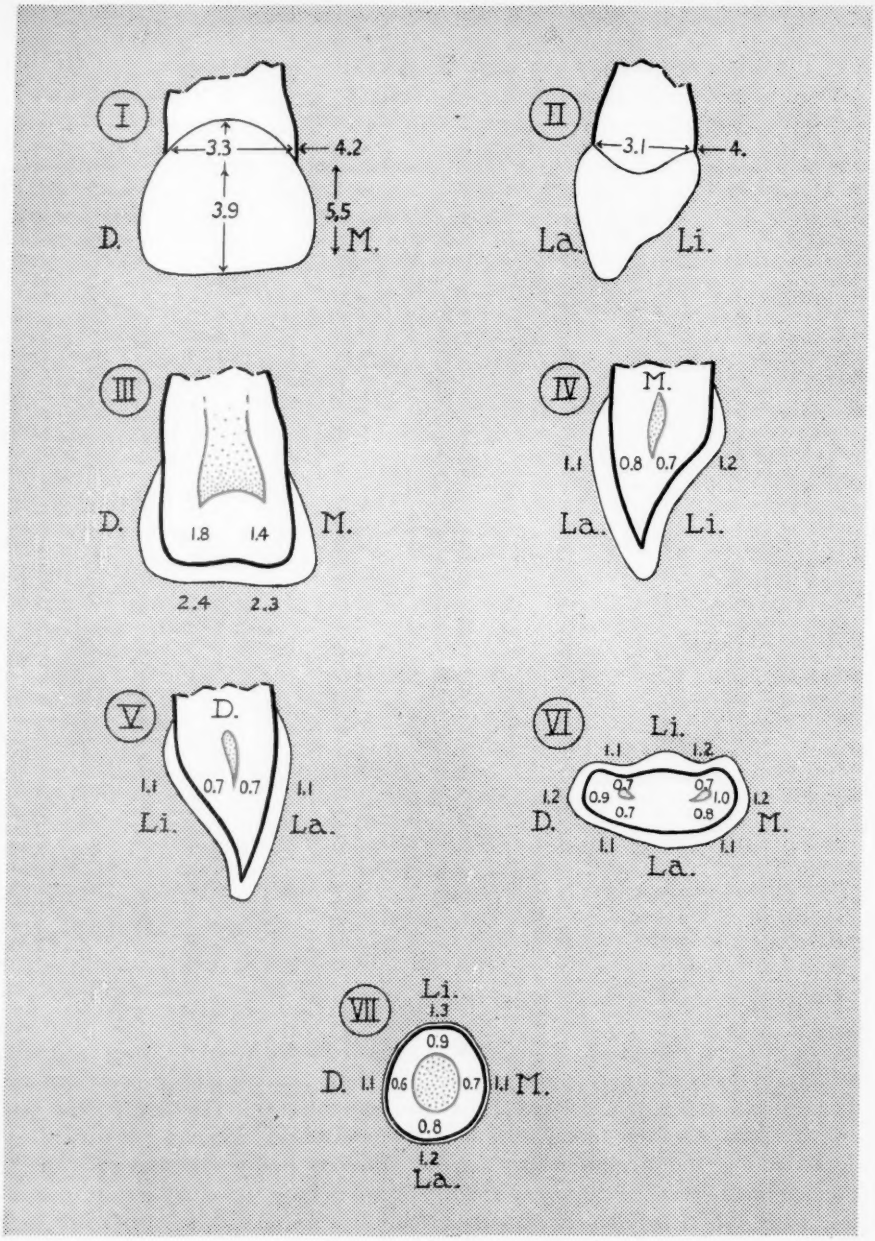

FIGURE 1. MAXILLARY CENTRAL PRIMARY INCISOR *A*.

I. Height and mesiodistal width of crown, II. Labiolingual width of crown, III. Tips pulp horns to dentino-enamel junction, incisally, IV. Pulp horn to dentino-enamel junction, mesial aspect, V. Pulp horn to dentino-enamel junction, distal aspect, VI. Tips pulp horns to dentino-enamel junction, horizontal section, VII. Pulp chamber to dentino-enamel junction at cervix, horizontal section. All measurements are in millimeters. Shortest distances are recorded inside the drawings, average distances outside.

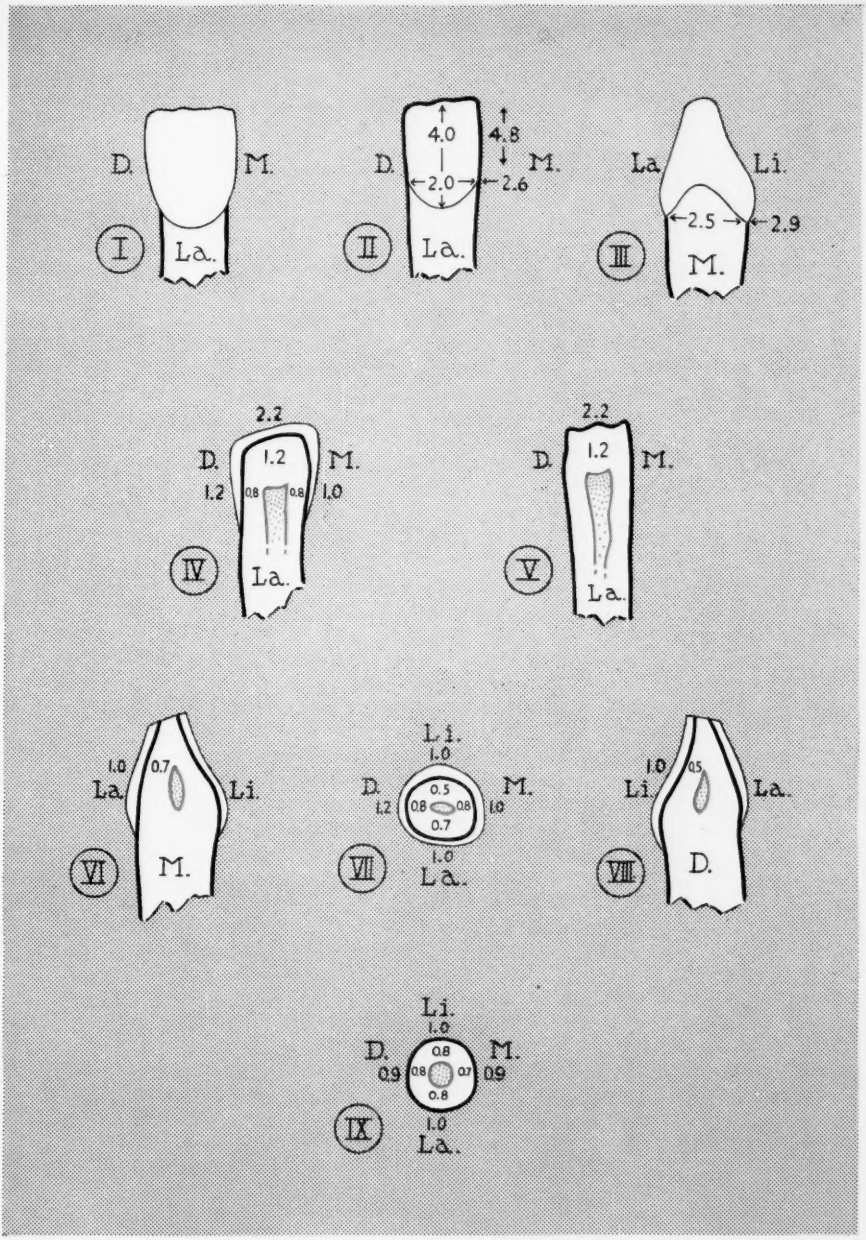

FIGURE 2. MANDIBULAR CENTRAL PRIMARY INCISOR $\overline{A}$.

I. Labial aspect, II. Labial aspect after demineralization, with height and mesiodistal width of crown, III. Labiolingual width of crown, IV. Tips pulp horns to dentino-enamel junction, incisally, V. Mesiodistoaxial section after demineralization, VI. Pulp horn to dentino-enamel junction, mesial aspect, VII. Pulp horn to dentino-enamel junction, distal aspect, VIII. Tip pulp horn to dentino-enamel junction, horizontal section, IX. Pulp chamber to dentino-enamel junction at cervix, horizontal section. All measurements are in millimeters. Shortest distances are recorded inside the drawings, average distances outside.

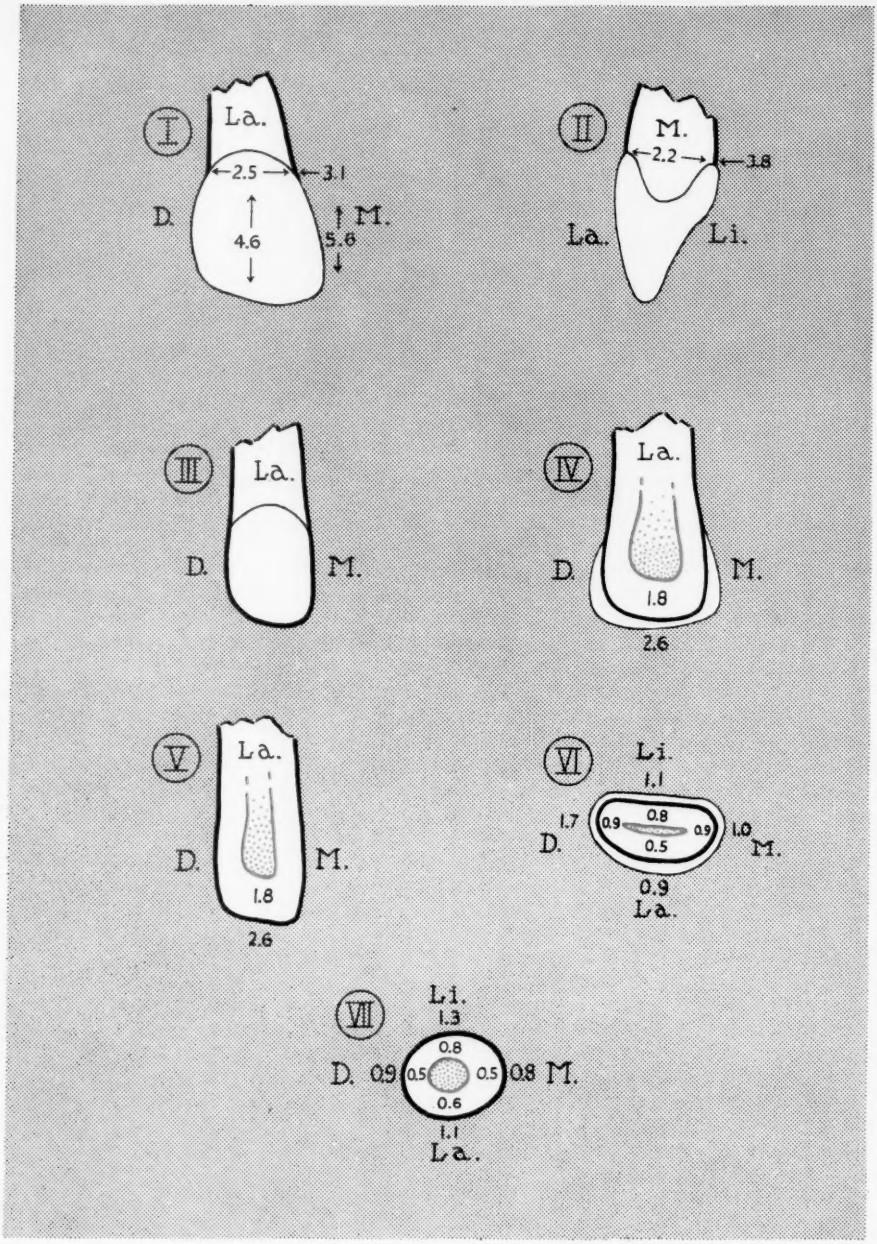

FIGURE 3. MAXILLARY LATERAL PRIMARY INCISOR *B*.

I. Height and mesiodistal width of crown, II. Labiolingual width of crown, III. Labial aspect after demineralization, IV. Tip pulp horn to dentino-enamel junction incisally, V. Tip pulp horn to dentino-enamel junction incisally, after demineralization, VI. Tip pulp horn to dentino-enamel junction, horizontal section, VII. Pulp chamber to dentino-enamel junction at cervix, horizontal section. All measurements are in millimeters. Shortest distances are recorded inside the drawings, average distances outside.

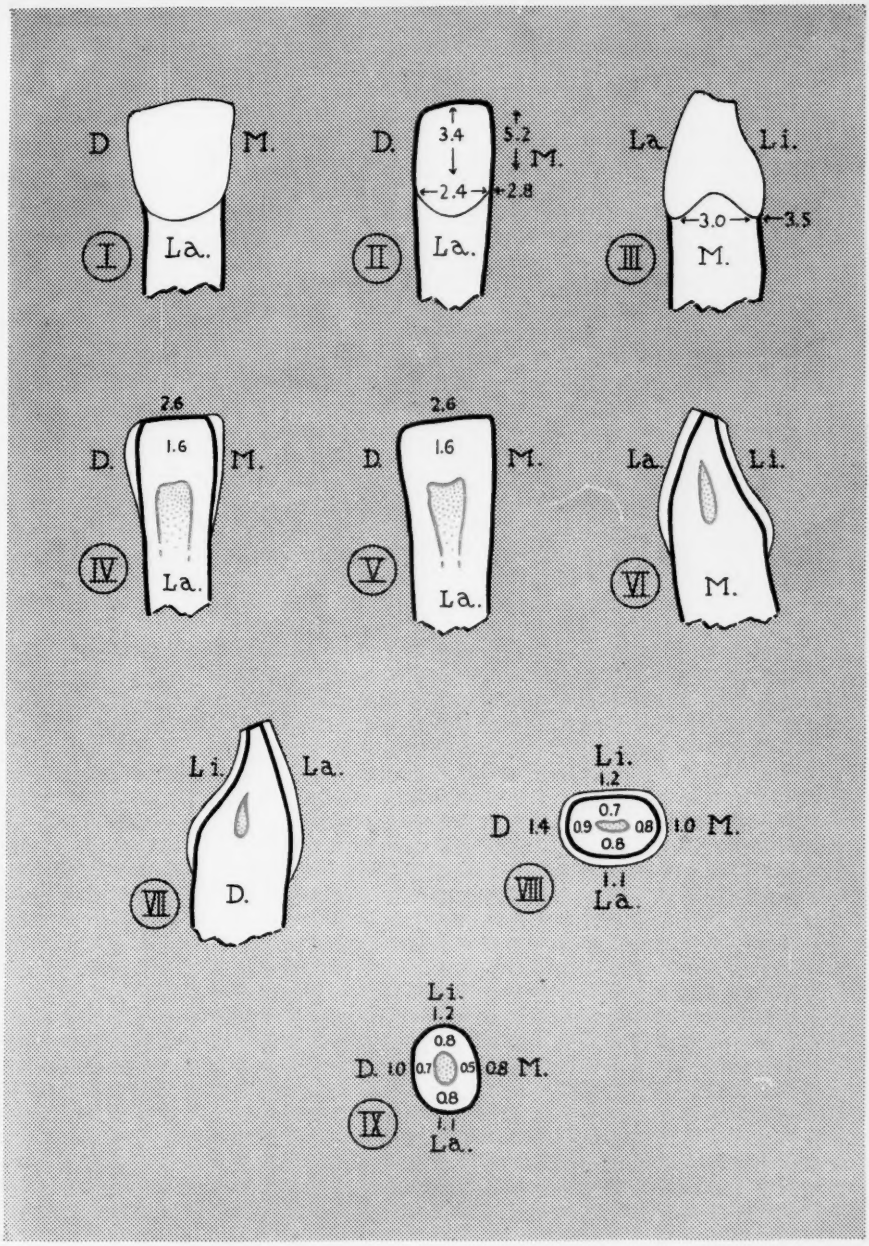

FIGURE 4. MANDIBULAR LATERAL PRIMARY INCISOR $\overline{B}$.

I. Labial aspect, II. Labial aspect after demineralization, with height and mesiodistal width of crown, III. Labiolingual width of crown, IV. Tips pulp horns to dentino-enamel junction, incisally. V. Mesiodistoaxial section after demineralization. VI. Pulp horn to dentino-enamel junction, mesial aspect, VII. Tip pulp horn to dentino-enamel junction, horizontal section, VIII. Pulp horn to dentino-enamel junction, distal aspect, IX. Pulp chamber to dentino-enamel junction at cervix, horizontal section. All measurements are in millimeters. Shortest distances are recorded inside the drawings, average distances outside.

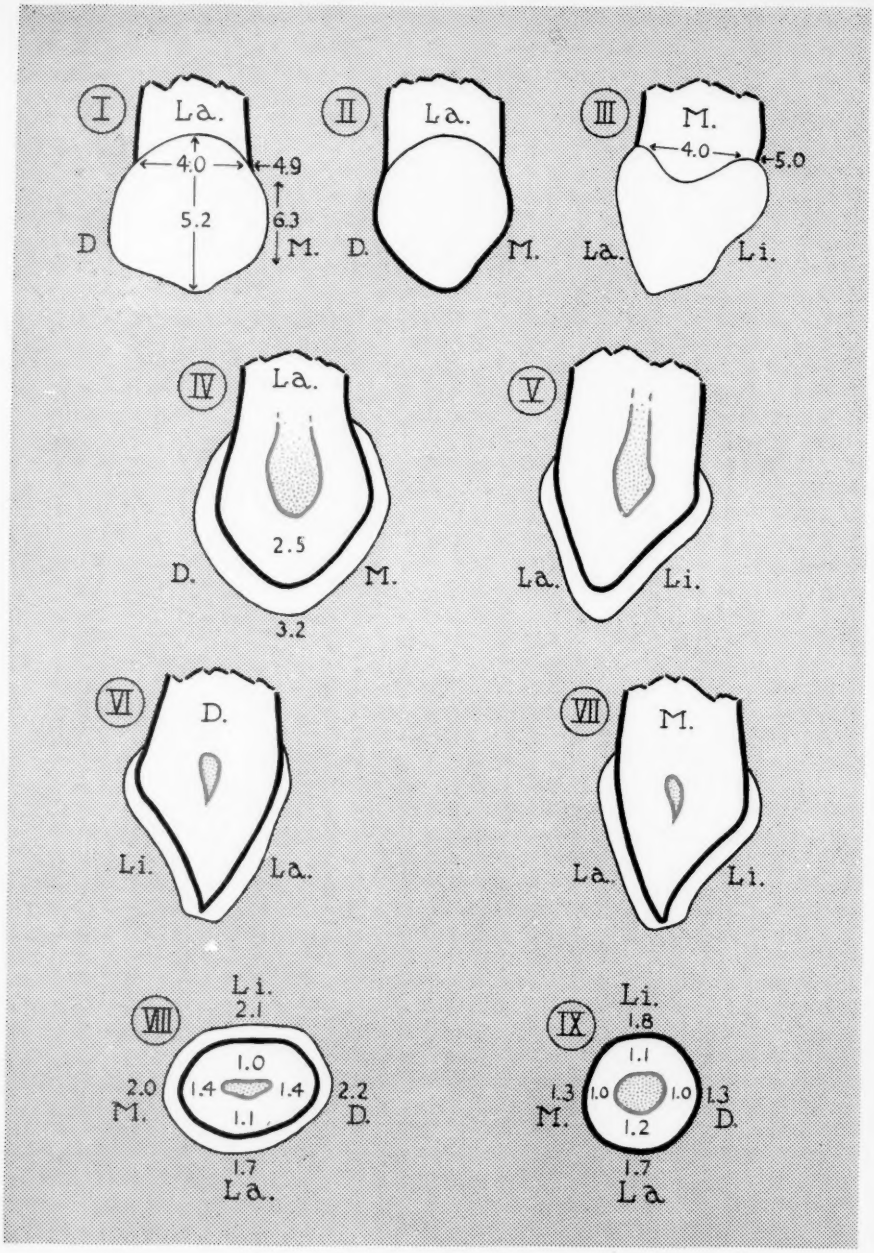

FIGURE 5. MAXILLARY PRIMARY CUSPID C.

I. Height and mesiodistal width of crown, II. Labial aspect after demineralization, III. Labiolingual width of crown, IV. Tip pulp horn to dentino-enamel junction, incisally, V. Labiolinguoaxial section through center of pulp, VI. Pulp horn to dentino-enamel junction, distal aspect, VII. Pulp horn to dentino-enamel junction, mesial aspect, VIII. Tip pulp horn to dentino-enamel junction, horizontal section, IX. Pulp chamber to dentino-enamel junction at cervix, horizontal section. All measurements are in millimeters. Shortest distances are reorded inside the drawings, average distances outside.

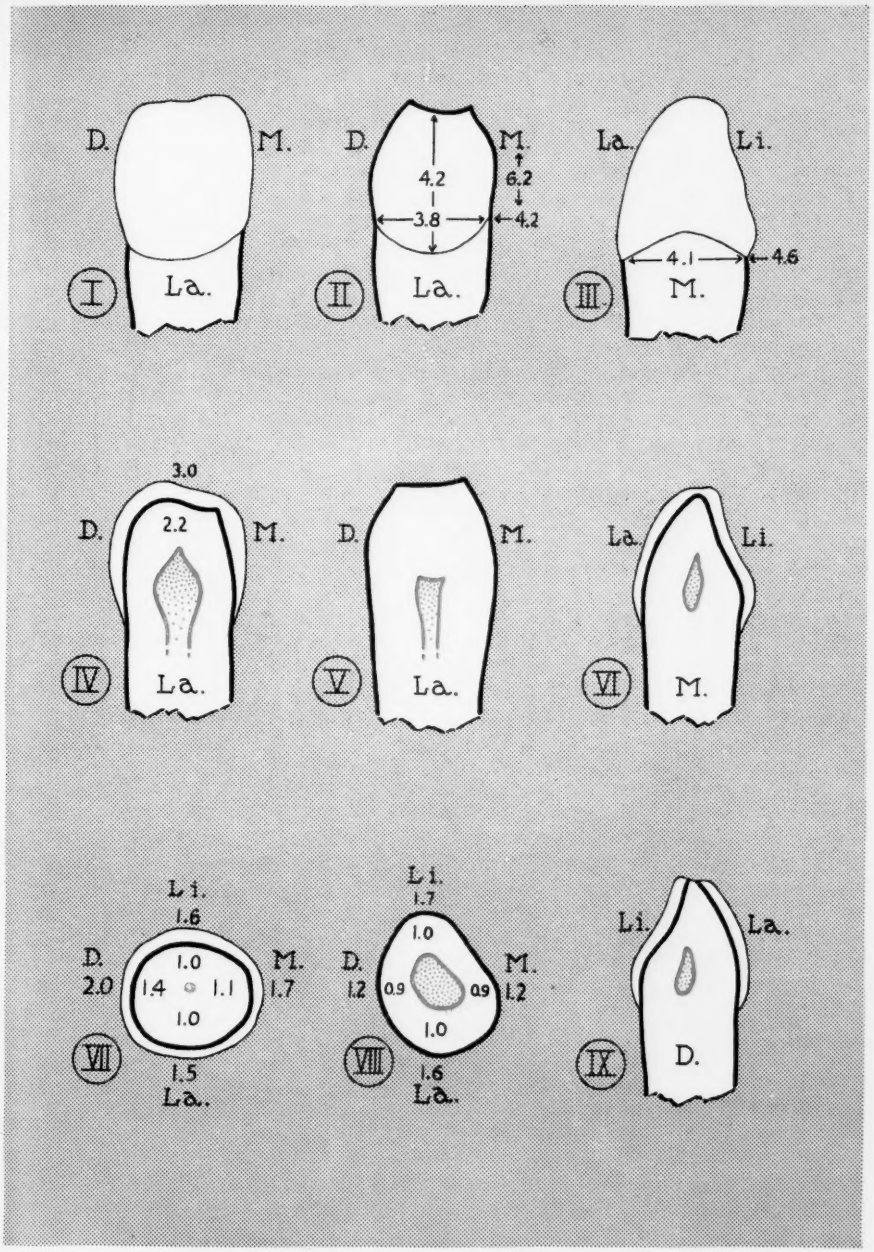

FIGURE 6. MANDIBULAR PRIMARY CUSPID $\overline{c}$.

I. Labial aspect, II. Labial aspect after demineralization, with height and mesiodistal width of crown, III. Labiolingual width of crown, IV. Tips pulp horns to dentino-enamel junction, incisally. V. Mesiodistoaxial section after demineralization. VI. Pulp horn to dentino-enamel junction, mesial aspect, VII. Tip pulp horn to dentino-enamel junction, horizontal section, VIII. Pulp chamber to dentino-enamel junction at cervix, horizontal section, IX. Pulp horn to dentino-enamel junction, distal aspect. All measurements are in millimeters. Shortest distances are recorded inside the drawings, average distances outside.

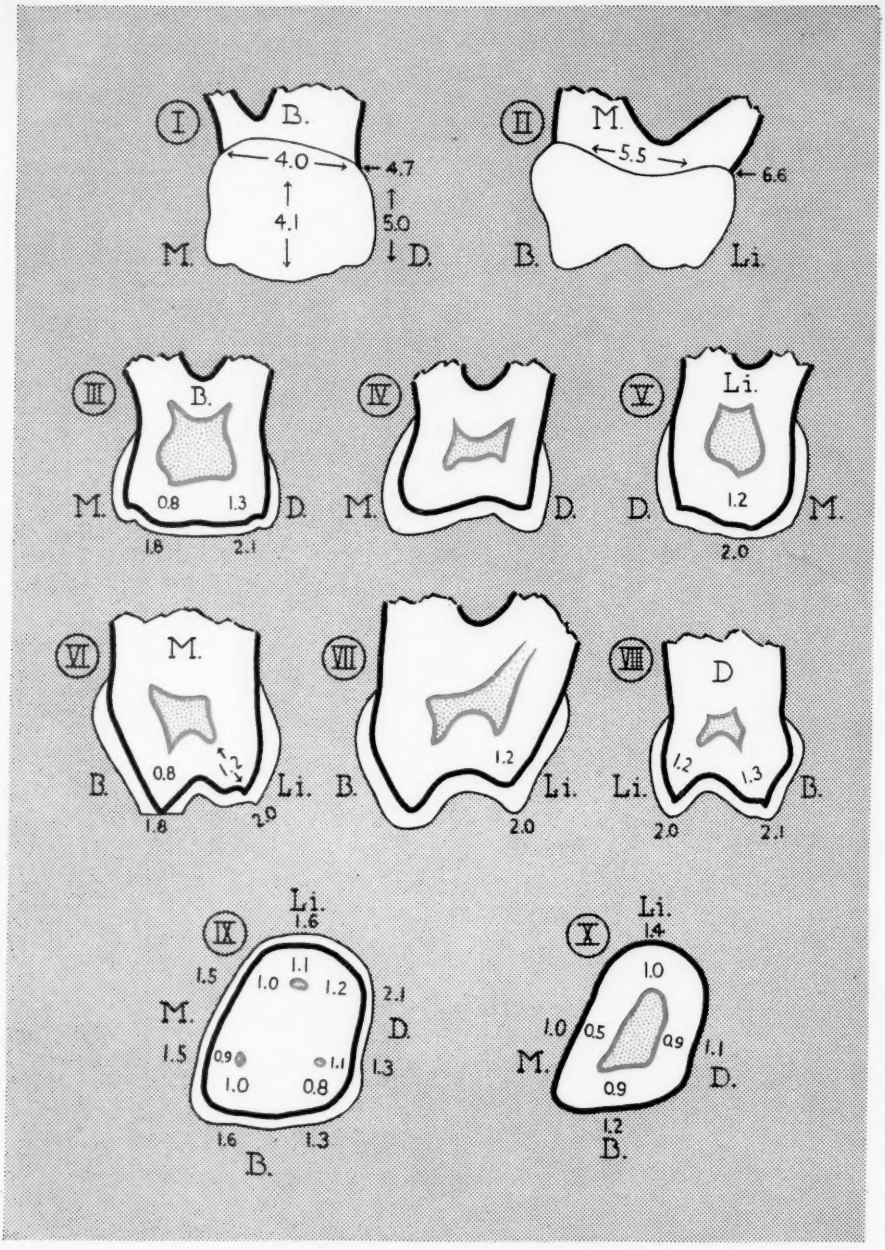

FIGURE 7. MAXILLARY FIRST PRIMARY MOLAR *D*.

I. Buccal aspect with height and mesiodistal width of crown, II. Buccolingual width of crown, III. Tips buccal pulp horns to dentino-enamel junction, occlusally, IV. Mesiodistoaxial section through center of pulp, V. Tip lingual pulp horn to dentino-enamel junction, occlusally, VI. Tips mesial pulp horns to dentino-enamel junction, occlusally, VII. Buccolinguoaxial section through center of pulp, VIII. Tips distal pulp horns to dentino-enamel junction, occlusally, IX. Tips pulp horns to dentino-enamel junction, horizontal section, X. Pulp chamber to dentino-enamel junction at cervix, horizontal section. All measurements are in millimeters. Shortest distances are recorded inside the drawings, average distances outside.

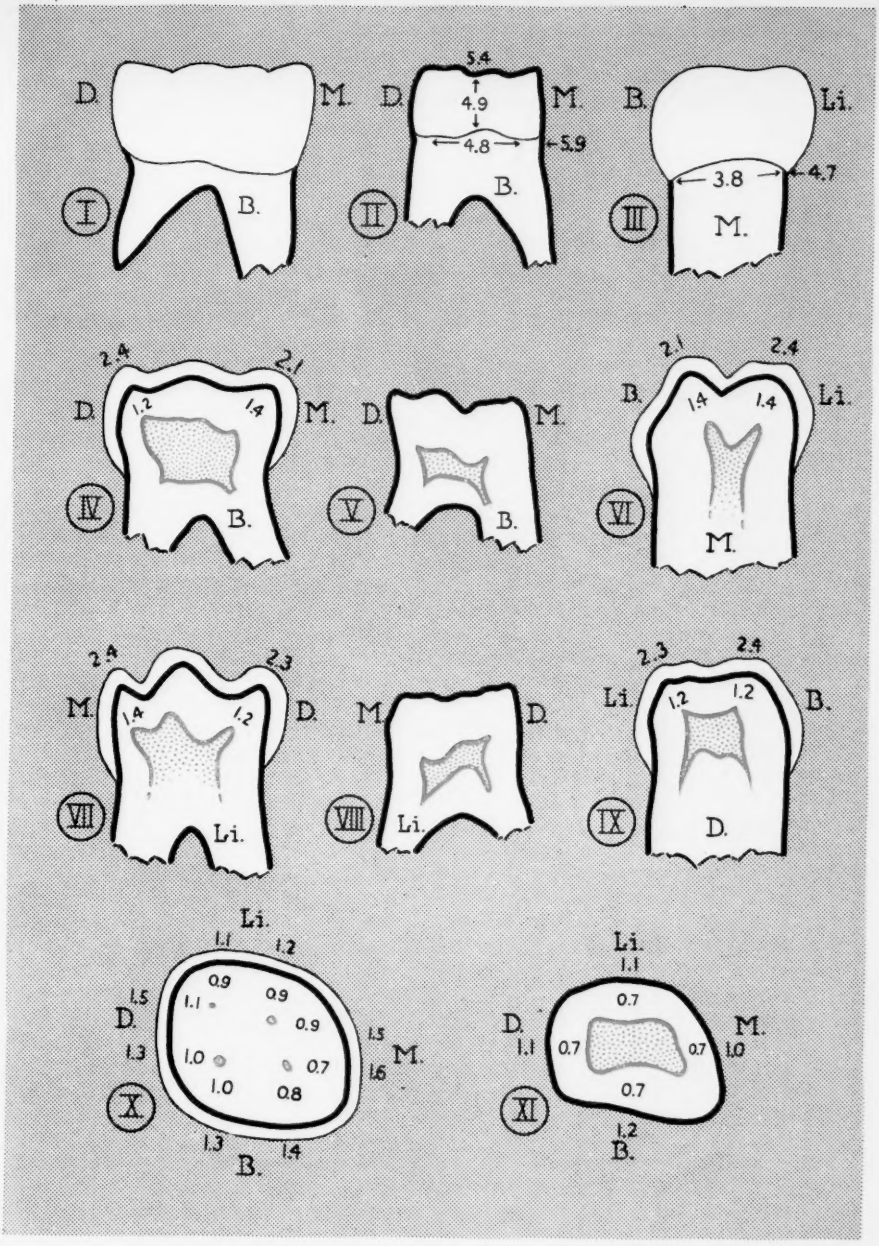

FIGURE 8. MANDIBULAR FIRST PRIMARY MOLAR $\overline{D}$.

I. Buccal aspect, II. Buccal aspect after demineralization, with height and mesiodistal width of crown, III. Buccolingual width of crown, IV. Tips buccal pulp horns to dentino-enamel junction, occlusally, V. Buccal pulp horns mesiodistoaxial section after demineralization, VI. Tips mesial pulp horns to dentino-enamel junction, occlusally, VII. Tips lingual pulp horns to dentino-enamel junction, occlusally, VIII. Lingual pulp horns mesiodistoaxial section after demineralization, IX. Tips distal pulp horns to dentino-enamel junction, occlusally, X. Tips pulp horns to dentino-enamel junction, horizontal section, XI. Pulp chamber to dentino-enamel junction at cervix, horizontal section. All measurements are in millimeters. Shortest distances are recorded inside the drawings, average distances outside.

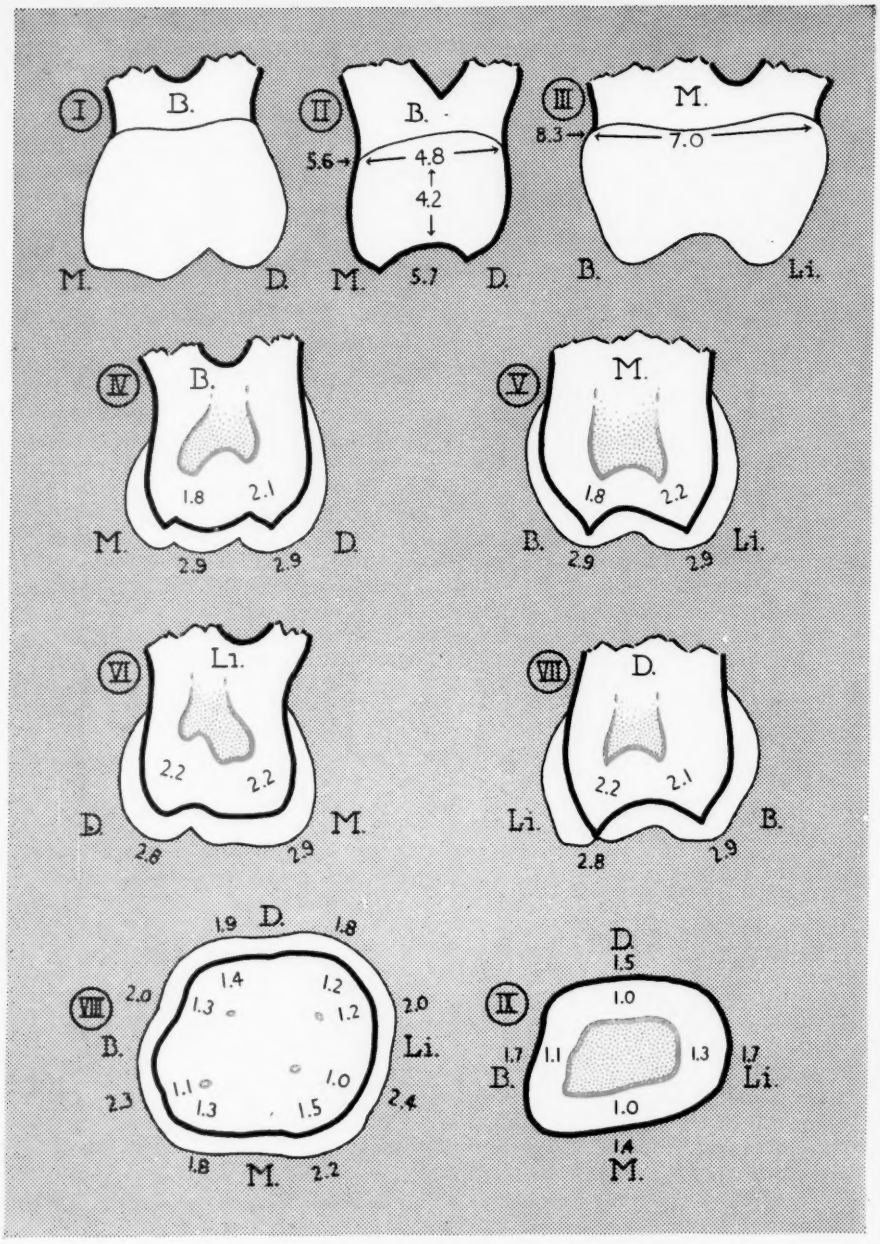

FIGURE 9. MAXILLARY SECOND PRIMARY MOLAR *E*.

I. Buccal aspect, II. Buccal aspect after demineralization, with height and mesiodistal width of crown, III. Buccolingual width of crown, IV. Tips buccal pulp horns to dentino-enamel junction, occlusally, V. Tips mesial pulp horns to dentino-enamel junction, occlusally, VI. Tips lingual pulp horns to dentino-enamel junction, occlusally, VII. Tips distal pulp horns to dentino-enamel junction, occlusally, VIII. Tips pulp horns to dentino-enamel junction, horizontal section, IX. Pulp chamber to dentino-enamel junction at cervix, horizontal section. All measurements are in millimeters. Shortest distances are recorded inside the drawings, average distances outside.

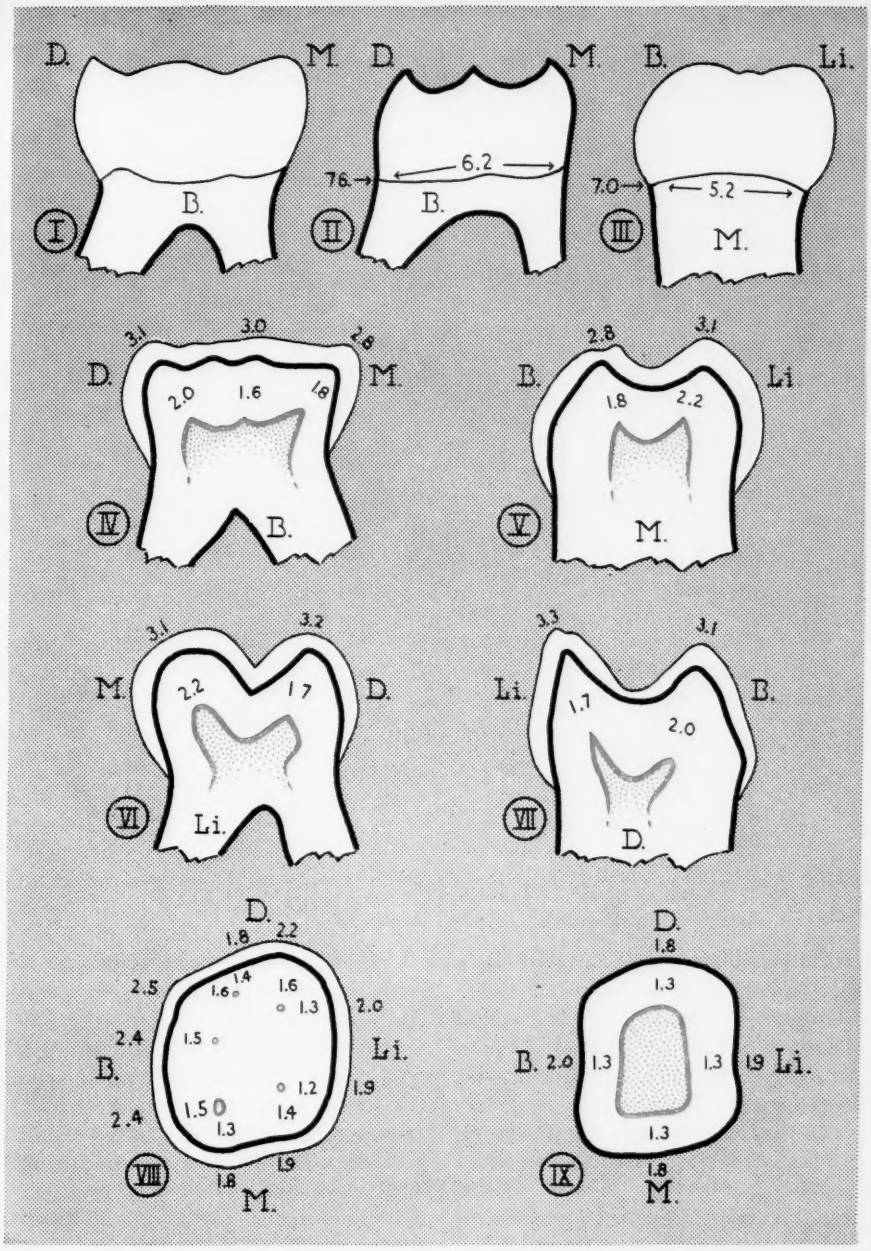

FIGURE 10. MANDIBULAR SECOND PRIMARY MOLAR $\overline{E}$.

I. Buccal aspect, II. Buccal aspect after demineralization, III. Buccolingual width of crown, IV. Tips buccal pulp horns to dentino-enamel junction, occlusally, V. Tips mesial pulp horns to dentino-enamel junction, occlusally, VI. Tips lingual pulp horns to dentino-enamel junction, occlusally, VII. Tips distal pulp horns to dentino-enamel junction, occlusally, VIII. Tips pulp horns to dentino-enamel junction, horizontal section, IX. Pulp chamber to dentino-enamel junction at cervix, horizontal section. All measurements are in millimeters. Shortest distances are recorded inside the drawings, average distances outside.

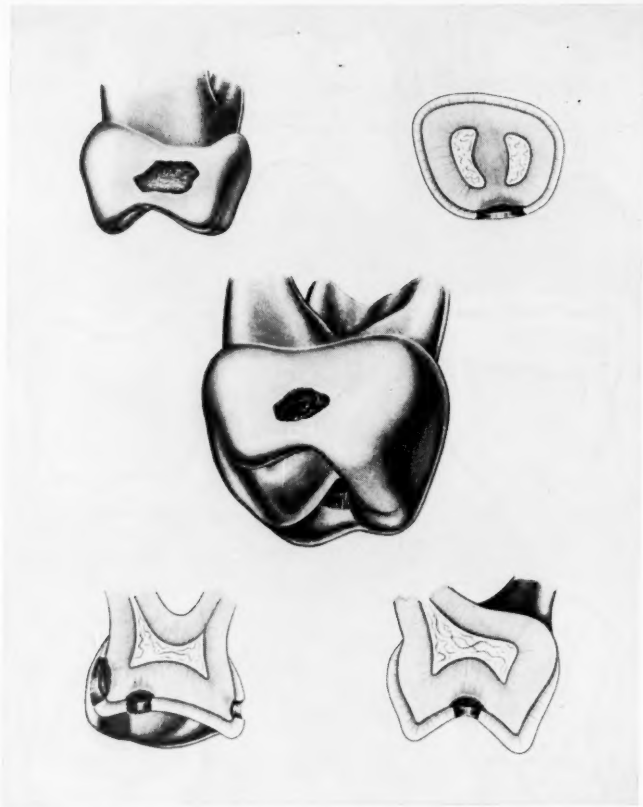

FIGURE 11. Maxillary first primary molar with carious lesions on mesial, distal and occlusal surfaces. Horizontal, mesiodistoaxial and buccolingual sections reveal the spatial relations between the lesions, the enamel, dentino-enamel junction, dentin and pulp.

around it; but it cannot be used safely for retention unless the floor of the cavity follows the dentino-enamel junction in contour.[12, 13, 22] It is easy to nick pulp horns if flat occlusal floors are extended bucco-lingually in molars,

The distal dentin was usually a little thicker mesio-distally than that found on the mesial, especially in the cervical areas. The buccal and the lingual dentin were thicker than the mesial or the distal; and in the anterior teeth, in the cervical region, the lingual dentin was thicker than the labial.

Certain general observations can be made which are not clearly shown in the tables and figures. More root resorption was found on anterior teeth than on posteriors. The anterior teeth, with the exception of the maxillary lateral incisors, were abraded more than the posteriors. The maxillary central incisors and mandibular cuspids were worn the most and the maxillary second molars the least. All teeth studied had some secondary dentin and most was seen in the second molars.

Little difficulty was encountered in

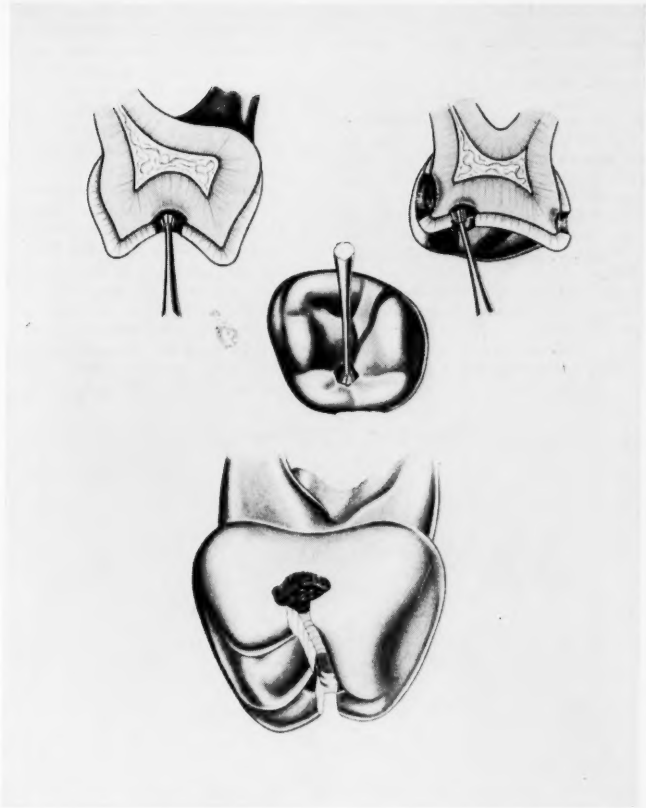

FIGURE 12. Initial cut with 33½ inverted cone bur from mesial to distal following dentino-enamel junction of occlusal surface.

finding anterior teeth relatively free of carious lesions but the dentin of the distal of the first molars and the mesial of the second had been destroyed frequently by the carious process. This is such a common occurrence that it has clinical significance in that all 8 molars often need restorations at the same time. The dentist can save time for himself and his patient if he operates on several teeth during the same appointment.[3]

In order to visualize the meaning of the data presented herein it is suggested that dental students and dentists dissect teeth, especially those with carious lesions, and study for themselves the spatial attributes of enamel and dentin in relation to the lesion, the pulp, the cutting instruments and restorative materials. Such study leads to a higher standard of professional service and a more efficient operation.

SUMMARY

The dimensions of coronary dentin of the primary teeth are recorded in this paper with suggestions concerning their clinical application.

BIBLIOGRAPHY

1. SCHOUR, I. and PONCHER, H. G. Rate of apposition of enamel and dentin measured by the effect of acute fluorosis. Am. J. Dis. Child. 54:757-776, Oct. 1937.
2. HOFFMAN, M. M. and SCHOUR, I. Quantitative studies in the development of the rat molar, I. The growth pattern of the primary and secondary dentin (from birth to 500 days of age). Anat. Rec. 78:233-251, Oct. 1940.
3. WILLIAMS, QUINTON E. and ARNIM, SUMTER S. Conservation of deciduous teeth using high speed and Willett inlays. J. Den. Children. 26:94-105, Second Q. 1959.
4. WEDELSTAEDT, E. K. A system of measurement of teeth and some ideal cavities. Dental Cosmos XXXIX: 375-391, 1897.
5. WEDELSTAEDT, E. K. Some advance in the system of measurement. Dental Cosmos XXXIX: 981-989, 1897.
6. BRONNER, F. J. Engineering principles applied to class II cavities. J. D. Res. 10:115, Feb. 1930.
7. BRONNER, F. J. Quoted from MILLER, S. C. Oral Diagnosis and Treatment. Ed. 2, Philadelphia, Pa. Blakiston 1946, pp. 386-415.
8. WILLETT, R. C. Inlay restoration for deciduous molars. D. Items Interest 50:345-350, May 1928.
9. KURER, J. Die schmelz-dentinstarke der milchzahne. Zschr. Stomatol. 18:1253-1259, 1937. Abstracted in Yearbook of Dentistry, Chicago, Ill. The Yearbook Publishers 1938, pp. 289-292.
10. KURER, J. Notes and comments (deciduous molar cavity preparation). Brit. D. J. 101:244, 1956.
11. RUSSMAN, SUMNER A. A study of the pulp chamber anatomy in deciduous dentition. Thesis, Master of Science in Dentistry for Children, University of Michigan, June 1947.
12. SWEET, CHARLES A. Cavity preparation in deciduous teeth. J.A.D.A. 38:423, April 1949.
13. BROWN, WILLIAM E. A mechanical basis for the

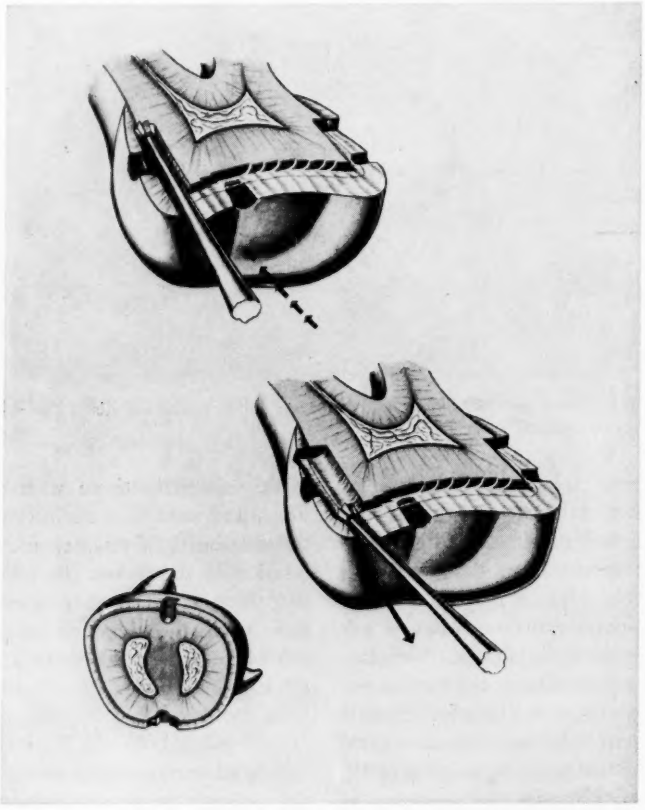

FIGURE 13. Extension of occlusal excision, gingivally, on mesial and distal. Depth of cavity is .5 mm. from dentino-enamel junction toward pulp. This depth is recommended only for average or more than average dentin thickness.

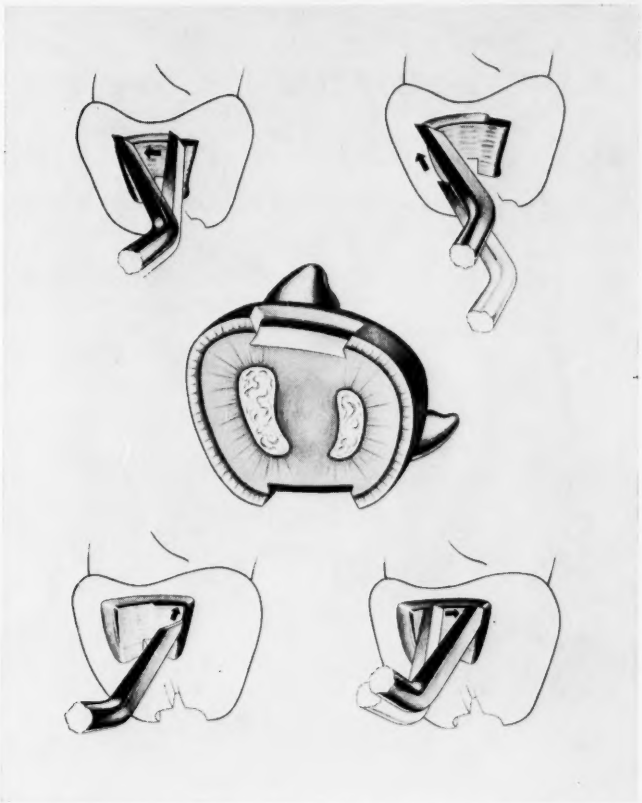

FIGURE 14. Use of hand instruments, enamel hatchets 10-80-8-14 and 10-95-8-14 R & L. for buccolingual extension and mortising of the proximal parts of the preparation. Note that instruments 1 mm. wide overlap cavity margins.

preparation of the class II amalgam cavity in primary molars. J.A.D.A. 38:417, April 1949.

14. HOPEWELL-SMITH, ARTHUR. Dental Anatomy and Physiology, Philadelphia, Pa., Lea and Febiger 1913, p. 226.
15. ZEISZ, ROBERT C. and NUCKOLLS, JAMES. Dental Anatomy. St. Louis, C. V. Mosby 1949, p. 458.
16. KRAMER, WM. S. and IRELAND, RALPH L. Anatomical measurements of the primary teeth of man. I.A.D.R. Preprinted abstracts, page 58, March 1956.
17. HUMPHREY, W. P. and FLEEGE, F. J. Restoration of fractured anterior teeth with steel crowns. J. Den. Children 20:178-179, Fourth Q. 1953.
18. DIDNER, D. Standardiserat djup po kaviteter och preparationer. (Standardized depths in cavities and preparations.) Odontologisk Tidskrift, 5:491, 1950.
19. IRELAND, RALPH L. Recent advances in operative dentistry for children. J.A.D.A. 49:277, Sept. 1954.
20. LAMPSHIRE, EARLE L. An evaluation of cavity preparations in primary molars. J. Den. Children, 22:3, 1955.
21. STEWART, D. J. and STEPHENS, RICHARD R. Diamond instruments designed for deciduous molar cavity preparation. Brit. D. J. 101:107-110, Aug. 1956.
22. STEWART, D. J. Modified diamond instruments for the treatment of carious and pre-carious fissures. Brit. Dent. J. 106:73-76, Jan. 1959.
23. MAHLER, DAVID B. An analysis of stresses in a dental amalgam restoration. J. D. Res. 37:516-526, June 1958.
24. LANGELAND, KAARE. Tissue changes in the dental pulp, an experimental histologic study. Odontologisk Tidskrift 65:239-395 Utgivningsdatum 28.8 1957.
25. ARNIM, SUMTER S. Conservation of the dental pulp, cavity preparation. In print.
26. JARDENI, I. Volumetric changes in fixed tooth specimens. A preliminary investigation. Brit. D. J. 74:1-3, Jan. 1943.

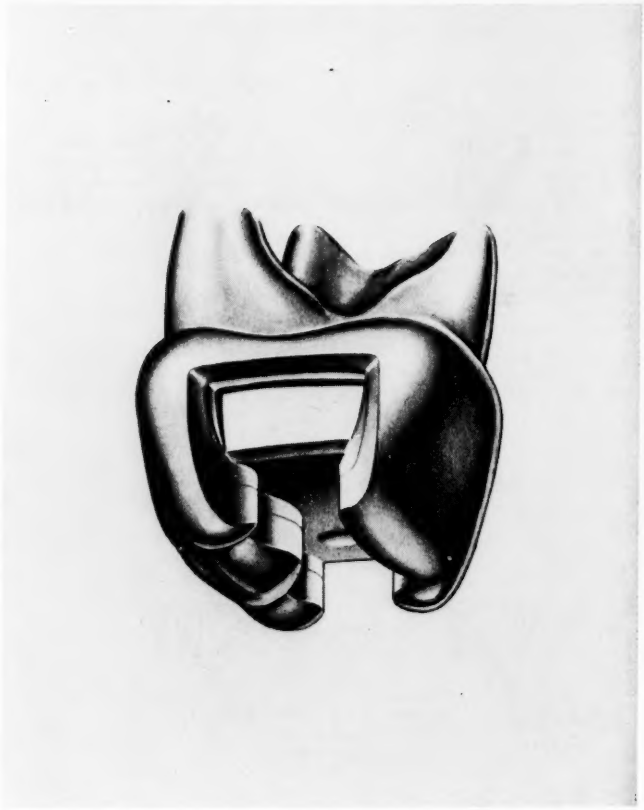

FIGURE 15. The completed cavity preparation.

PRELIMINARY PROGRAM AND PRE-REGISTRATION DATA, 1959 ANNUAL MEETING, AMERICAN SOCIETY OF DENTISTRY FOR CHILDREN

NEW YORK CITY
FRIDAY, SATURDAY AND SUNDAY—SEPTEMBER 11, 12, 13, 1959

REGISTER EARLY

SOCIAL PROGRAM

FRIDAY, September 11, 1959—
4:00 P.M. Registration and Knickerbocker Welcome Party, at which you will be guests of the New York State Society of Dentistry for Children
Evening free for theatre, N. Y. C. tours, etc.

SATURDAY, September 12, 1959—
10:30 A.M. Coffee Break
11:00 A.M. For the Ladies:
Brunch and Fashion Show at the Waldorf-Astoria Hotel, Jade and Basildon Rooms (door prizes, including a portrait in oil of the winning guest)
1:00 P.M. Scientific Luncheon, Hotel Commodore
6:30 P.M. Cocktail Party and President's Banquet, Grand Ballroom, Hotel Commodore

SUNDAY, September 13, 1959—
10:30 A.M. Coffee Break
2:00 P.M. For the Ladies:
Guided Tour of the United Nations Building
4:30 P.M. "ALOHA" Farewell Party

THE SCIENTIFIC PROGRAMS

SATURDAY, September 12, 1959—
9:00 A.M.-10:30 A.M. Registered Clinics
11:00 A.M.-12:00 Noon Problem Clinics
12:30 P.M.- 1:30 P.M. Scientific Luncheon

THE SCIENTIFIC LUNCHEON

The plan for the Scientific Luncheon (which is another innovation for A.S.D.C. Meetings) is as follows: At each table (seating ten) a scientific subject, announced beforehand, will be discussed during and after lunch. At each table there will be one of the clinicians of our Registered or Problem Clinics to lead the discussion and a member of the Scientific Program Committee to guide it.

Members who attend the Luncheon will choose the table they wish and will remain there throughout the Luncheon and discussion.

Scientific exhibits, visual education, projected clinics and lectures are also being arranged for Friday afternoon, Saturday and Sunday.

SUNDAY, September 13, 1959—
9:00 A.M.-10:30 A.M. Registered Clinics (Repeated)
11:00 A.M.-12:30 P.M. Demonstration and Table Clinics (No special registration required)
2:00 P.M.- 4:00 P.M. Panel Discussion

BUSINESS MEETINGS

Friday, 3 P.M. Executive Council Meeting
All A.S.D.C. members are invited
Saturday, 2 P.M. State Delegates Meeting
3 P.M. General Membership Meeting

REGISTERED CLINICS

1. FIXED AND REMOVABLE PROSTHESIS FOR CHILDREN
DR. ALBERT L. ANDERSON, San Diego, California
Past President, American Society of Dentistry for Children, and
DR. JACK LONGLEY
Pedodontist.

2. CLINICAL ORAL PATHOLOGY
DR. CHARLES L. BOYER
Instructor of Pediatric Dentistry, Harvard University, School of Dentistry; Member of Staff of Children's Medical Center, Boston.

3. ORTHODONTICS AND DENTISTRY FOR CHILDREN
DR. WILLIAM BROWN
Associate Professor of Pedodontics, University of Michigan, School of Dentistry; Member—American Board of Pedodontics.

4. PRESERVATION OF INFECTED PRIMARY MOLARS
DR. M. MICHAEL COHEN
Stomatologist, Boston Floating Hospital; Faculty, Tufts University School of Medicine; Author of Pediatric Dentistry.

5. INJURIES TO THE TEETH OF CHILDREN
DR. ROY ELLIS
Dean of Faculty, Professor of Operative Dentistry, School of Dentistry, University of Toronto; Author of Injuries to the Teeth of Children.

6. TRAINING THE CHILD PATIENT
DR. SIDNEY B. FINN
Professor of Dentistry, University of Alabama; Author of Clinical Pedodontics.

7. PULPAL MANAGEMENT IN THE PRIMARY AND YOUNG PERMANENT DENTITION
DR. JOSEPH T. HARTSOOK
Associate Professor of Dentistry, University of Michigan, School of Dentistry, Ann Arbor, Michigan.

8. HABITS
DR. SAMUEL HEMLEY
Professor of Orthodontics, New York University, College of Dentistry; Author of Orthodontic Theory and Practice.

9. AMALGAM RESTORATIONS
DR. RALPH IRELAND, Lincoln, Nebraska
Dean and Professor of Pedodontics, University of Nebraska, College of Dentistry; Secretary—American Board of Pedodontics.

10. DIAGNOSIS AND TREATMENT PLANNING IN PEDODONTICS
DR. PAUL LOSCH
Associate Professor of Pediatric Dentistry, Harvard University School of Dentistry; Chief of Dental Department of Children's Medical Center, Boston.

11. PRACTICE MANAGEMENT IN PEDODONTICS
Dr. Melvin Noonan
Pedodontist, Birmingham, Michigan.

12. CONTROL OF PAIN IN PEDODONTIC PRACTICE
Dr. Norman Olsen
Associate Professor and Chairman of Department of Pedodontics, Northwestern University, School of Dentistry.

13. HEALTH EDUCATION
Mr. Perry Sandell, Chicago, Illinois
Director of Bureau of Dental Health Education, American Dental Association.

14. HOSPITALIZATION FOR THE ROUTINE CARE OF EXCEPTIONAL CHILDREN
Dr. George Teuscher
Dean and Professor of Pedodontics, Northwestern University, School of Dentistry; Member—American Board of Pedodontics.

15. CARIES CONTROL
Dr. Joseph F. Volker
Dean of School of Dentistry, University of Alabama.

16. PRACTICE MANAGEMENT IN PEDODONTICS
Dr. Roy Wolff
Pedodontist, St. Louis, Missouri.

17. HOW TO PRESENT DENTAL HEALTH TO CHILDREN OF ALL AGES
Jacob Zack, B.A., M.A.
Principal, Boys High School, Brooklyn, N. Y.; Author of Public Speaking in Dental Health Education . . . *Basic Course.*

PROBLEM CLINICS AND SPECIAL PROGRAMS

1. ANKYLOSED TEETH
Dr. Elias Fass, Fairfield, Connecticut
Instructor of Pedodontics, New York University, College of Dentistry; Diplomate of American Board of Pedodontics.

2. INTERCEPTIVE ORTHODONTICS
Dr. Sidney Kohn, Jersey City, New Jersey
Professor of Pedodontics, Fairleigh Dickinson University Dental School; President of American Board of Pedodontics.

3. INTERNAL RESORPTION OF PULPOTOMIZED TEETH
Dr. Ralph McDonald
Professor of Pedodontics, Indiana University, School of Dentistry; Member of American Board of Pedodontics.

4. ROOT CANAL THERAPY FOR PRIMARY TEETH
Dr. Bernard Z. Rabinowitch, Beverly Hills, California
Diplomate of American Board of Pedodontics.

5. PUBLIC HEALTH DENTISTRY—THREAT OR PROMISE TO THE PEDODONTIST
Dr. Harry Draker
Assistant Director, Department of Dentistry, New York State Department of Health.

6. ORTHODONTIC REHABILITATION AND INTERCEPTION
   DR. LOUIS A. SIMON
   Assistant Director, Bureau of Dentistry, New York City.
   DR. SARA GRAY
   Dental Consultant, Bureau of Dentistry, New York City.

7. SPACE MAINTAINER FOR THE MISSING PRIMARY MOLAR
   By the STUDENT PEDODONTIC SOCIETY OF NEW YORK UNIVERSITY.

TABLE CLINICS AND DEMONSTRATIONS

(A Partial Listing)

1. JOHN A. BOGERT, D.D.S., Kansas City, Missouri
   "Oral Malignancies of Children."
2. A. E. IVERSON, D.D.S., Kansas City, Missouri
   "The Management of Injuries to the Young, Permanent and Primary Anterior Dentition."
3. BENEDICT B. KIMMELMAN, D.D.S., Philadelphia, Pennsylvania
   "Toothbrushing, Its Techniques and Values."
4. J. P. MCGUIGAN, D.D.S., Halifax, Nova Scotia
   "A Simple Intermediary Method of Protecting and Restoring to Function Fractured Anterior Teeth."
5. W. NEAL NEWTON, D.D.S. and JOHN E. GILSTER, D.D.S., St. Louis, Missouri
   "Full Denture Service for the Patient with Anhydrotic Ectodermal Dysplasia."
6. JULIAN B. RAFFKIND, D.D.S. and KENNETH L. CATHEY, D.D.S., San Antonio, Texas
   "Custom Matrix Band Technique."
7. MARVIN SNIDERMAN, D.D.S., Pittsburgh, Pennsylvania
   "Prescription Writing."
8. PAUL STARKEY, D.D.S., Dayton, Ohio
   "The Use of the Rubber Dam in Pedodontics."
9. JEROME D. TEITELBAUM, D.D.S., Valley Stream, New York
   "At What Age Should a Patient be Referred to an Orthodontist?"
10. WALTER S. WEISZ, D.D.S., Pittsburgh, Pennsylvania
    "The Reduction of Dental Decay by the Use of a Sodium Fluoride Mouthwash."
11. HUGH M. KOPEL, D.D.S. and ZALMAN KONIKOW, D.D.S., Detroit, Michigan
    "The Treatment of Drug Reactions in Pedodontics."
12. JOSEPH C. MUHLER, D.D.S., Bloomington, Indiana
    "The Clinical Use of Stannous Fluoride."
13. WILLIAM P. HUMPHREY, D.D.S., F.A.C.D., Denver, Colorado
    "Use of Chrome Steel in Dentistry for Children."
14. FRANK H. DANIEL, D.D.S., North Carolina
    "Preventive Orthodontics for the Child Patient."
15. STANLEY J. BEHRMAN, D.D.S., New York, New York
    "Clinical Oral Pathology in the New Born."
16. MORRIS KELNER, D.D.S., New York, New York
    "The Physiology and Rationale of Treatment of the Traumatized Maxillary Permanent Anterior Tooth."
17. KENNETH M. PLATZER, Brooklyn, New York
    "Orthodontic Aids in Dentistry for Children."
18. WILLIAM H. SUNLEN, D.D.S., Alachua County, Florida
    "Case Presentation in Children's Dentistry."

SYMPOSIUM ON PULP THERAPY

SUNDAY, SEPTEMBER 13—2:00 P.M.

Moderator

DR. MAURY MASSLER

Professor and Head of the Postgraduate Department of Pedodontics, University of Illinois, College of Dentistry.

LECTURER:
DR. BERNARD Z. RABINOWITCH
Diplomate—American Board of Pedodontics, Beverly Hills, California.

SUBJECT:
"Pulp Capping for Primary and Immature Permanent Teeth."

LECTURER:
DR. MICHAEL BUONOCORE
Research Coordinator Eastman Dental Dispensary, Rochester, New York.

SUBJECT:
"Vital Pulpotomy for Primary and Immature Permanent Teeth."

LECTURER:
DR. CHARLES A. SWEET, JR.
Former Associate Professor and Head of the Department of Pedodontics, University of Southern California.

SUBJECT:
"Therapeutic Pulpotomy for Primary Teeth."

LECTURER:
DR. ISRAEL BENDER
Chief of Department of Dentistry, Albert Einstein Medical Center, Northern Division, Philadelphia, Pennsylvania.

SUBJECT:
"Pulpectomy for Primary and Immature Permanent Teeth."

THE ORGANIZATION OF EFFECTIVE COMMUNITY DENTAL HEALTH PROGRAMS*

WESLEY O. YOUNG, D.M.D., M.P.H.**

EDITOR'S NOTE:

One of the most influential and hard working of our Standing Committees is the Committee on Community Dental Programs, headed up by Wesley O. Young, whose accompanying paper is the first of four prepared as committee activity during the past year.

The entire series is well worth your reading time.

A.E.S.

DENTAL diseases have become so common that, for many individuals, they are more a part of normal living than a source of concern. Dental caries, for example, frequently starts before the second birthday and often has been experienced by more than 80 per cent of children entering school. To complicate the problem, only a small proportion of carious lesions are receiving professional attention, so that the need for treatment accumulates and becomes more complex as children grow older. The end result is that a large number of children are already dental cripples by the time they become adults.

Logically, members of the dental profession who have recognized that children's dental needs demand priority have also taken the leadership in the development of dental public health programs. Because these leaders were aware that the practicing dentists could influence only a small portion of the children and parents in a community, they encouraged the organization of community programs of prevention and education to supplement the practitioner's efforts.

The American Society of Dentistry for Children has reflected the interest of its membership in the development of community dental programs through its Standing Committee on Community Dental Health Programs. This committee has done an excellent job for a number of years in promoting preventive procedures and encouraging the participation of A.S.D.C. members in organized community dental health activities. To carry on this work the current committee has developed a series of papers for the JOURNAL which are designed to assist the membership in promoting the establishment of more adequate dental health services in their own communities. This paper, the first in the series, outlines the steps essential in the development of an effective community dental program.

Analysis of Problem. Community dental health programs are particularly effective because they can be planned specifically to meet the needs of the community involved. An important prerequisite to program planning, therefore, is a careful study of the needs and resources of the community.

The study of needs should include a dental survey, an analysis of the water supply and a determination of what dental problems are considered important by the individuals in the community itself. Such an appraisal would determine

* The first in a series of papers prepared under the direction of the Committee on Community Dental Programs, A.S.D.C.

** Chief, Dental Health Section, Idaho Department of Health, Boise, Idaho.

the current DMF and def rates for preschool and school children, the prevalence of soft tissue diseases and developmental anomalies, and the fluoride content of the water supply. The attitude of the teachers in the schools toward dental health teaching and the content of the health curriculum should also be investigated. The geographic distribution of the children should be studied as well as any special cultural or ethnic problems which influence diet or attitudes toward obtaining dental care.

An analysis of the available community resources would include a determination of the number of dentists in the community who provide treatment for children and the number of school health or health department employees who might be available to assist in educational activities. It would be important to find out the resources that are available to finance care for children from indigent families and the treatment facilities available for children with crippling handicaps such as polio and cerebral palsy. The programs and resources of voluntary health organizations are among the other factors that should be studied.

Planning for a dental program should involve representatives of all the organizations in the community which have or should have an interest in improving dental health conditions. Usually, it will be wise to organize representative advisory committees during the initial community survey. These groups can then assist in the collection of data and will be ready to proceed with program planning as soon as the study of the community has indicated the problems to be overcome.

Program Planning. The planning group cannot be too large, but it should involve as broad a representation of the community as possible. The dental health problem is basically a community one and its solution will require action by many people. Most of the individuals selected to assist in the planning and establishment of the program work with children in their roles as parents, school personnel or health department employees and will have valuable suggestions which should not be overlooked. Furthermore, the involvement of a large number of the community leaders in the planning of a program will assure more active participation and interest when it is put into effect.

Generally it will be found advisable to select an individual to coordinate the planning activities and to see that they result in definite action. The coordinator may be a health department or school health worker, a practicing dentist, or a volunteer worker. Some state dental divisions have sufficient personnel to assign a dentist, dental hygienist, or health educator to the community for a period of time to share the responsibility of coordinating planning activities, developing written policy statements and implementing the recommendations of the advisory committees.

Fortunately, a careful evaluation of the needs and resources of the community ordinarily will make fairly self-evident the proper objectives of a local program and the type of activities that should be carried out. It will also help to determine which objectives should have top priority. Clearly defined objectives are important prerequisites of effective action and will make possible, at a later date, to evaluate whether or not progress is being made.

Program Objectives. A local dental health program should be centered

around prevention, health education, and the provision of dental care but the relative priority for the three types of services will be determined by community needs.

The first priority for preventive procedures should be given to controlled fluoridation, if the water supply is naturally deficient. In some instances, however, a fluoridation campaign may not be immediately practical—or there may not be a satisfactory central water supply that can be fluoridated. In such instances the organization of a community program for the provision of topical fluoride applications is the method of choice. The effectiveness of fluorides is limited largely to the prevention of dental caries. The promotion of correct health habits of toothbrushing, good oral hygiene and correct diet is important for the reduction of both carious and soft tissue lesions. The effectiveness of these preventive measures is determined by the adequacy of a health education program.

A major objective of dental health education is to teach correct health habits which will enable a child to take care of his own mouth properly. It is also important to teach facts about dentistry which will assure rational decisions about dental care when the children are old enough to assume the responsibility for their own health. Health education activities in the past probably have concentrated too exclusively on the problems of dental caries. Although this is the primary problem during childhood and adolescence it would seem that school and community health programs should emphasize also the problems of periodontal disease so that young adults are not totally unaware of the hazards inherent in periodontal disturbances.

Although modern preventive procedures can reduce the attack of dental disease, teeth will still decay and gingival tissues become inflamed. Consequently, unless early and regular dental care is instituted, the loss of teeth and function is inevitable. The promotion of dental care, therefore, becomes an important component of any community dental health program. Despite the progress that has been made in the past, children receiving regular dental care are probably still in the minority. Many families who could afford adequate dental care do not seek treatment because they are not convinced of its importance to their children's future well-being. Health education activities directed to this group of parents should have a high priority in the planning of a community health program.

Unfortunately there are still many individuals in the community who cannot obtain care for financial or other reasons. The largest segment of these individuals is medically indigent. A smaller, but perhaps more dramatic group, are those children afflicted with handicaps such as cerebral palsy and mental retardation which make the provision of care in routine practice difficult and expensive. The organization of facilities for the treatment of both indigent and handicapped children is an important responsibility of a community dental health program. In some areas this may be done directly by the health agency or school sponsoring the program. Treatment may be provided in the offices of private practitioners, in school or health department clinics, or in mobile dental units. In other areas a greater emphasis may be placed upon the organization of community facilities to take care of these children outside the framework of the

community dental health program itself.

Program Administration. Since public health programs involve working with a community instead of individual patients, special training and skills are necessary for effective operation. A community dental health program should be under the leadership of trained public health workers in order to assure that the time and money expended will bring maximum results.

In larger communities public health leadership is obtained relatively easily by the employment of full-time personnel. A large program may require the services of a public health dentist to administer the program, public health dental hygienists to assist in the educational activities and a number of clinical dentists and dental hygienists to provide dental care. Somewhat smaller programs may be staffed by a dentist who administers the program and also provides some clinical care. An increasing number of communities look to a public health dental hygienist to carry out educational activities and coordinate the other phases of the program which are carried on by professional people already in the community such as practicing dentists and dental hygienists. Small communities may be able to carry out effective programs by utilizing only the professional personnel already in the community. In all instances—but particularly in the smaller programs—a community should avail itself of the consultant services of the dental division of the state health department.

Evaluation. In all of the steps that have been outlined previously the skills of a public health specialist will be of value. The most important contribution, however, may well be in the field of program evaluation. All too frequently, activities are initiated and carried out for years without a critical analysis of whether or not they continue to be effective. Evaluation must frequently determine not only whether a particular activity is valuable, but whether the time expended is most efficiently used for this purpose. Evaluation does not necessarily imply a full-scale technical investigation, but often can be done informally while the program is in operation. Periodically, a more complete evaluation of the program should be done. If the program has been well designed and conceived and the objectives clearly stated it is frequently possible to measure results in quantitative terms. For example, if one of the primary objectives of a program is to reduce the amount of dental decay, a DMF survey before and after several years of operation should show whether or not this end has been attained. Similarly, if one of the objectives of the program was to increase the amount of dental care received, the same DMF surveys will show whether or not a larger percentage of children are receiving fillings after the operation of the program.

Summary. Dental diseases continue to be a major health problem because of an almost universal attack and frequent neglect. Community dental health programs improve dental health conditions, particularly among children, through organized and concentrated community efforts to supplement the preventive, educational and treatment services of the private practitioner.

A careful survey of the needs and resources of the community is the first step in the organization of an effective program. Program planning, based on the results of the community survey, should be done in cooperation with a group of individuals who are broadly represent-

ative of the community. The type of dental program will vary according to the needs of the community but it should include preventive, educational and treatment aspects. The skills of competent public health workers should be available to assist in planning, conducting and evaluating the community program, either on a full-time or on a consultant basis.

REFERENCES

PELTON, W. J., and WISAN, J. M. Dentistry in Public Health. 1st Edition, Philadelphia and London, W. B. Saunders Co., 24-44, 187-238, 1949.

PELTON, W. J., and WISAN, J. M. Dentistry in Public Health. 2nd Edition, Philadelphia and London, W. B. Saunders Co., 11-46, 167-217, 1955.

HEALTH EDUCATION ACTIVITIES IN COMMUNITY DENTAL PROGRAMS*

PERRY SANDELL**

HEALTH education, briefly stated, is the process of effecting a change in the health behavior of an individual. The change in behavior may be for the better or the worse, depending upon the integrity of the educational program. There is much going on in the way of education in dental health that has an undesirable effect. One has but to watch television advertising of various dental health products or to read advertisements in newspapers and magazines to realize how many things have an influence on a person's, particularly a child's, behavior.

Motivating people to practice acceptable dental health procedures and to develop proper attitudes toward dental health and dental care is not easy but it is possible. Prevention and control of dental disease require continuous and definite effort on the part of the individual.

What motivates people to accept and practice desirable health measures is a complex question. Some people are motivated through example, some by a simple desire to be healthy, some because they realize the results of neglect of health. Attempts have been made through research to determine why people do, or do not, seek dental care. Results have not been too encouraging. The answers people give to these questions apparently are not the real reasons. It is clear, however, that all people are not motivated by the same conditions.

When people are asked why they have not seen a dentist in the last year they give such answers as: my teeth are fine; I don't need to go; I haven't had a toothache or it costs too much. None of these reasons seems reasonable to a dentist but they, with many others, apparently contribute to the neglect of oral health.

Why do parents neglect their children's teeth? Here again we can only speculate. When one realizes that one of the primary concerns of a mother is the health of her young child, we must assume that, if dental health is neglected, she does not understand its importance. A recent survey[1] indicates that many

* Second in a series of papers prepared under the direction of the Committee on Community Dental Programs.

** Director, Bureau of Dental Health Education, American Dental Association.

mothers have little or no knowledge concerning the importance of professional or home care of the primary teeth.

The income of the family, no doubt, has some effect on whether or not dental care is obtained. But one study[2] has shown that, perhaps, income is not so important as might be thought. What is more significant than income seems to be the importance that is attached to the teeth. The family's sense of values determines to a large extent how the available money is spent. Dental health does not hold a high position on the scale of values of many people.

The dentist, it seems to me, has two responsibilities in the community dental health education program: educating the patients in his practice and cooperating with his colleagues in the dental society and with other community groups in a program of public education.

It may seem unusual, and perhaps it is, to include patient education in the community dental health education program. The community program, however, is made up of many factors. Surely the education that does or does not go on in the dentist's office must have its effect on the dental health of the community. A dentist who does not utilize educational technics in his practice cannot be expected to be very useful in a community dental health education program.

Teachers tell us that education is most effective when the pupil feels a personal need for learning—when he can associate learning with his own experience. A patient in a dental chair must have felt a need or in all probability he would not be there.

It is inconceivable that there is any dental operation that does not lend itself to a lesson in dental health. A dental prophylaxis, a simple filling or extraction, the replacement of a missing tooth or treatment of a periodontal condition—all of these provide an opportunity for the dentist to "bring home" a lesson in dental health. The hygienist, likewise, has many opportunities for building proper patient attitudes and creating a better understanding of the need for personal and professional care.

Psychologists say that an informed individual is more likely to pursue the proper course of action. The "keep the patient in ignorance" attitude has no place in modern dental practice. Dentistry will achieve its proper position among the health professions only when the public understands and accepts dental care as a basic health need. This requires education.

Dentists have many educational aids to help them in their program, to save valuable time. Charts, pamphlets, slides, models and posters are available. Each of these can serve a useful purpose. A pamphlet on periodontal disease will help reinforce what the dentist has told the patient about his condition. It will give the patient a better understanding of the problem he faces and what needs to be done about it. Every mother of young children can be helped to a better appreciation of the importance of care of the primary teeth if the dentist gives her a booklet covering the subject.

The *Principles of Ethics* of the American Dental Association provide the basis for the dentist's participation in community health programs. Section 4, *Leadership,* states: "The dentist has the obligation of providing freely of his skills, knowledge and experience to society in those fields in which his qualifications entitle him to speak with professional competence. The dentist should

be a leader in his community, especially in all efforts leading to the improvement of the dental health of the public." Section 20, *Health Education of the Public,* has this to say: "A dentist may properly participate in a program of health education of the public involving such media as the press, radio, television and lecture, provided that such programs are in keeping with the dignity of the profession and the custom of the dental profession of the community."

An active local dental society with a sincere interest in the improvement of the health of the public will find all the communications media willing to cooperate. A brief discussion of each of the media will serve to point out the many possibilities for an educational program.

The Press. Nearly every community is served by a newspaper published locally or in a neighboring city. It is important for the dental society to establish a good working relationship with the newspapers.

Evidence of editors' interest in printing material on health is the fact that most newspapers carry syndicated health columns. Editors will usually publish news stories or feature articles on health subjects if they are authoritative and well presented.

If the dental society has no member capable of writing a news story on dental health and if no one else is available locally who can do this, the society can obtain materials from the Bureau of Public Information of the American Dental Association.

Radio. Although television is challenging radio as a means of mass communication, radio should not be forgotten as a medium for health education. It is still the best means for reaching many people who cannot be reached by other media.

Radio stations are required to allot a certain amount of time to non-profit, public service programs. Some dental societies have been able to obtain a considerable amount of time for dental health education programs by working with station owners and operators.

The program formats most frequently used are the dental health talk, the interview and the panel discussion. The type of presentation is not so important as the subject matter, the personalities and the voices of the people on the program.

How effectively radio can be used depends on the time available, the ability of the participants and the quality and timeliness of the subject matter. If the dental society cannot have its program material produced locally, a number of scripts can be obtained from the Bureau of Public Information of the American Dental Association.

Television. Sight and sound together communicate ideas more effectively than either of them used alone.

Television presents the same problems of obtaining time and of producing materials as radio does. If the best use is to be made of television, the health message must be illustrated by props such as models, charts, graphs and slides. A number of dental health films have been cleared for use on television, some without charge.

Information on films, slides and filmstrips for television is available from the film library of the American Dental Association.

Talks and Printed Material. There are numerous opportunities in every community for the dental society to schedule talks on dental health for various groups. Civic clubs, women's clubs, P.T.A.'s and other similar organizations are interested in learning about health.

To handle requests for speakers, some dental societies have organized a speakers' bureau. It is the function of the bureau to schedule speakers, provide speech material, select and train speakers and in general to handle all details involved in the program.

Printed materials such as pamphlets, leaflets and posters may perform a valuable function in the community dental health program if they are used effectively. There is little, if any, value in the promiscuous distribution of literature. If the material is used to amplify and emphasize the objectives of the dental survey program, the value of fluoridation, the discussion at the preschool conference or any other dental health program in operation, then certainly it has value. Dental health education materials are available from most state and local health departments and from the American Dental Association.

Working With Other Groups. For a number of reasons, the dental society should work with schools in dental health education. Schools have a large captive audience and a very important one for the dental profession to contact. Schools have an interest in promoting and maintaining the health of children. Schools need help in their dental health education program. Schools have children during the years in which it is easiest to influence them in their dental health habits and attitudes.

An entire book could be written on the subject of school and dental society cooperation. In this paper it is perhaps enough to say that the dental society should familiarize itself with the health activities of the school and begin making plans for cooperative action. Dental societies can get advice and help in their program from the dental director in the state health department as well as from the Bureau of Dental Health Education of the American Dental Association.

There are many organizations interested in health. Search them out and offer to help. Here are a few: the Parent-Teacher Association, 4-H Club, Future Farmers of America, Girl Scouts, Boy Scouts, American Legion and Junior Chamber of Commerce.

Evaluation of the Program. The evaluation of a health education program is at best a difficult task. There may be no immediate results that are discernible. Frequently effects of a program may not be observed until some years later.

In patient education the dentist should have no difficulty in determining whether or not his efforts have been worthwhile. If the condition of the teeth and mouth of the patient improve from one visit to another and if the patient returns routinely for prophylaxis and treatment as suggested, then the dentist's efforts have not been in vain.

The objectives of a community dental health education program must be clearly stated if evaluation is to be possible. If among the objectives are to prevent dental disease, to save teeth and to restore defective teeth, then a baseline examination can be performed at the start of the program and a follow-up examination made at predetermined intervals. In this way the effects of the program can be measured.

In evaluating school dental health education programs, in addition to the foregoing, the status of dental health knowledge of school children at the start provides a basis for determining improvement in knowledge and attitudes. Has the sale of sweetened drinks and candy been eliminated from the school? Is encour-

agement given for routine visits to the dentist and is there follow-up of routine dental examination programs? Have the dental health educational materials used in schools been checked for authenticity? Does the school library contain adequate reference materials for dental health education? These are questions that need to be answered.

In conclusion, then, what is needed to conduct a community dental health education program? Most important, it is necessary to have a group of dentists who have a sincere interest in improving the health of the people in the community through a program of education.

The program of dental health education should be assigned to a committee composed of members willing to study and learn something about the technics of dental health education. This committee must be alert to the many possibilities for education and must be willing and able to work with other community groups in developing dental health education programs. The society must provide an adequate budget to take care of the operating expenses of the committee.

With these essentials and with the advice and guidance of state dental directors and the American Dental Association, programs can begin to grow and bear fruit.

222 East Superior Street
Chicago 11, Illinois

REFERENCES

1. MOEN, B. D. Family Dental Survey. Chicago, Bureau of Economic Research and Statistics, American Dental Association.
2. KOOS, EARL LOMAN. The Health of Regionville. New York, Columbia University Press, 1954, 177 pp.

FOR ADDITIONAL READING

From the Bureau of Dental Health Education, American Dental Association:

Suggestions and Guides for Dental Societies Planning Dental Health Education Programs
A Dental Health Program for Schools
Planning Dental Health Conferences
The Maintown Dental Health Project
The Dental Health Inventory for Maintown

From the Bureau of Public Information, American Dental Association:

Publicity for Dental Societies
Television Manual

OTHERS

PELTON, WALTER J., and WISAN, J. M. Dentistry in Public Health, 2nd Edition, Philadelphia and London, W. B. Saunders Co., 1955, 282 pp.
STOLL, FRANCES A.: Dental Health Education, Philadelphia, Lee and Febiger, 1957. 196 pp.

CONTRIBUTIONS OF COMMUNITY DENTAL PROGRAMS TO THE PRACTICE OF DENTISTRY FOR CHILDREN*

ROBERT L. WEISS, D.D.S., M.P.H.**

EVIDENCE that has been available for many years continues to point to the overwhelming and ever-present dental needs of the public and the accompanying problems facing the dental profession. Frequent attempts, through one means or another, have been made to resolve the problems inherent in the provision of adequate dental health services for children. Some methods have shown greater potential than others.

Experience has revealed that the establishment of organized local health programs has been an important factor

* Third in a series of papers prepared under the direction of the Committee on Community Dental Programs.

** Chief, Program Practices Section, Division of Dental Public Health, Public Health Service, Washington 25, D. C.

in solving the health problems of the community. Oftentimes, the community setting offers the only opportunity for direct contact between the ultimate recipients of health services, the public, and the individuals who provide these services. Experience also has shown that persistent recognition of the health needs of children by the community offers some assurance of success in its health endeavors. The health needs of children represent a substantial portion of the health needs of the total population. Inadequate health care for children, moreover, results in the problem of caring for the vast accumulated health needs of the adult population. Concerted effort directed toward meeting the health needs and maintaining a more adequate health status in children leads to an eventual decrease in the backlog of needs in adults.

In view of the success which has been experienced in solving other health problems, it is reasonable to assume that a community dental program, operating as a component of the total community health program, can be equally successful. Although community dental health programs as such are relatively few in number at present, accomplishments of these programs adds credence to this belief.

Community dental programs contribute to a more "adequate" practice of dentistry in addition to a more adequate oral health status of the population. Substantial contributions to the practice of dentistry for children and greater personal satisfactions to the dentist can be realized. However, it is important to keep in mind that community dental programs exist, basically, to benefit the recipient—namely, the public. At the same time, it must also be recognized that although professional ethics dictate that such programs should not exist for the purpose of contributing to dental practice or to the individual dentist, mutual benefits are derived and important contributions are offered to the practice of dentistry for children and to the individual dentist.

This discussion will point out some of the immediate and long-range contributions to the dental profession and to the dentist arising from an organized community dental program. In order to enhance this interpretation, a brief description of each dental program activity discussed precedes the statements referring to its tangential contributions.

In general, the community dental program represents an opportunity for the practicing dentist and the community to employ an auxiliary means of extending dental services beyond the individual dentist's capacities and time limitations. The extension of services through auxiliary means, employed in the office or in the community setting, results in mutual benefits to the community and the dentist. In some respects, the benefits to the dentist parallel those derived from the utilization of auxiliary personnel in his private office. For example, certain aspects of dental service requiring professional skills (such as the provision of topical fluoride applications, screening of patients and educating the community) can be augmented by delegating these types of activities to the dental hygienist employed in the community program. Obviously, this course of action can be followed only when such aspects of practice relate to community dental activities.

The community dental program provides a focal point at which all matters pertaining to the dental health of the

community converge. In the absence of an active local dental organization, the community program may represent the only unified front through which dental and public health matters of concern to the organized dental profession and the individual dentist may be handled at the local level. In some areas where dentists are few or where there are inherent difficulties in organizing a strong local dental society, the community dental public health program becomes the only avenue through which the dentist can be heard.

A community dental program also helps establish dentistry in the "health atmosphere" of the community. By nature of its creation, it exists as a coordinating mechanism between the dentists, other health workers of the community, and the community itself. Its daily routine reflects its basic interest in health and people. Its activities and accomplishments, supplementing those of private practice, augment the prestige of the profession and the dentist. The community dental program represents tangible evidence that the profession and its individual members are committed to providing a complete health service to the community.

Added benefits also can be gained through community educational activities aimed at the teacher, the nurse, and the physician. Dental instruction in modern medical, nursing, and teacher-training institutions appears to be a glaring deficiency. However, in addition to the opportunities which exist routinely in the community dental program, activities of a more specific nature can be planned in order to supplement the meager interest and knowledge of the medical and teaching professions whose exposure to the dental needs of children has been relatively limited.

Too frequently public health matters become the overwhelming burden of one or a few practitioners who, although interested in the problems of the community, can deal with these problems in a limited way only. An equal share of time and support from other members of the profession is usually lacking. The community dental program, on the other hand, presents a means of carrying out the total responsibility of the dental profession on an equitable basis. It offers a means of sharing this responsibility. For example, providing dental treatment to the indigent and other demands of the community may be handled jointly and effectively by all or several dentists in the community.

The dentist cannot always resolve community dental problems effectively with the resources available in a given local area. In these instances, demands for active participation in meeting community needs may appear to be an additional burden to the busy practitioner. However, the establishment of an organized community health program assures the dentist of a means of channeling National and State resources into his community and thus aid him in extending his services to the community. Federal and State programs designed to support local health activities are numerous. These include the provision of funds, personnel, and other assistance necessary for the promotion of health at the community level. Also, national organizations outside of government are becoming more dependent on local health units for administration and participation in the community aspects of their programs. Such services facilitate the private practitioner in meeting the dental health

problems of his community. Many such services are unavailable or difficult to identify unless channels to resources outside the community are open.

Community care or treatment programs, aimed at increasing dental services, are a basic element in many community dental programs. In most instances care programs are aimed at providing a more complete service to needy children. In communities where an organized dental care program does not exist, the scope of service to the indigent patient frequently is based on the minimal amount of time necessary to take care of isolated or emergency conditions —the amount of time available between scheduled appointments, for example. These situations can be frustrating to the dentist since they provide little opportunity to consider the adequacy of these services or to treat these patients in line with what his conscience dictates. On the other hand, the provision of indigent care through an organized community dental program allows the dentist to anticipate the demands of the community in caring for this kind of patient and, in turn, to provide a better service. In addition, most indigent care programs provide for payment for services, thus reducing to a minimum the personal sacrifice borne by the dentist.

Even greater benefits to the private practitioner accompany public health endeavors aimed at the non-indigent population. Referral programs have the potential of increasing the number of individuals seeking dental services and receiving frequent and periodic care. Such accomplishments result in increased productivity and subsequently lead to increased financial return to the practicing dentist. As a rule, patients receiving frequent and periodic dental attention offer the greatest potential for minimizing the strain and excessive demands of private practice. Effective referral programs will reduce the number of patients, predominant in many practices today, who require extensive oral treatment and rehabilitation.

In addition to referral programs, public health along with the dental profession has developed an intense interest in prepayment, postpayment, and other methods of financing dental care which allow for anticipating and budgeting its cost. Community programs as already demonstrated to some extent in urban areas can assist in the establishment of suitable plans for group payment. Along with assuming the responsibility of purchasing care for the indigent, community programs can assist in promoting the establishment of group payment plans for the public at large. Facilitating payment for services provided by the dentist has obvious advantages to the private practitioner as well as to the recipient of these dental services. These advantages relate to the business management of practice in addition to the financial aspects.

Community care programs offer the young dentist in the community an opportunity to develop interest and skill in treating children and contribute to the establishment of desirable patterns of dental practice in the community. Also the local program frequently serves as teacher and site for orientation programs for dentists and field training programs for recent graduates. Joint efforts of the public health agency and organized dentistry frequently have supplied continuing education activities focused on dentistry for children to local practitioners. Thus, opportunities exist to develop awareness and interest within

the profession through exposure to the needs of all children in the community. In turn, the development of awareness, interest, and skills in the young dentists of the community assure the established practitioner of continuing support in meeting the oftentimes staggering demands of the child population.

For many years preventive programs conducted at the community level consisted of little more than educational activities directed toward dietary control and proper oral hygiene practices. Preventive aspects of today's local program have been strengthened immensely through the inclusion of fluoridation and the topical application of fluoride. In most instances, adoption of these methods has been contingent upon an existing community dental program. Multifold benefits to the practicing dentist as well as the public naturally follow developments which lead to a substantial quantitative reduction in the occurrence of dental disease. A listing of these benefits is limited only by the confines of the imagination. For example, reductions in the occurrence of smooth-surface caries alone, as is evidenced following an adjustment of the fluoride level in a community water supply, forecasts an eventual reduction in the number of the more complex operative procedures presently required in coping with proximal caries. Undoubtedly, substantial savings in time can be realized by the private practitioner. In turn, at least a portion of the time presently spent in combating dental caries almost exclusively, can be devoted to other services which will lead to an increased level and scope of practice. Ultimately, a more desirable apportionment of time devoted to palliative orthodontics, periodontal treatment, and more complete diagnostic services could result.

Health education presented within the framework of a community program is a necessary adjunct to the limited educational activities conducted in the dental office. It is the only continuing means of assuring an informed public, the reservoir of practice. Educational activities such as providing factual information and nurturing a high level of understanding of dental health as it relates to the public promote sound attitudes. Sound attitudes, subsequently, contribute to motivation—that is, seeking routine dental treatment, utilizing preventive methods, and practicing good personal health habits. These responses would reduce the dire oral conditions frequently faced by the practicing dentist as a result of gross negligence. Again, as is true of treatment and referral programs, increased productivity, greater financial returns and a more desirable level and scope of practice would ensue.

It is interesting to speculate about the possible effects that health education might have on public appreciation for dental health. During the past few decades, the publicizing of events occurring in the field of dentistry and nationwide activities, such as the annual observance of Children's Dental Health Week, probably has had some effect. The pace, however, has been relatively slow. But it is possible to visualize a startling upsurge of interest in dental health, an upsurge of national consequence, if organized and continuing activities in the educational area were to become commonplace at the community level. Its effect on the private practice of dentistry might well be as startling.

Benefits to the practitioner derived from dental education programs presently conducted by the community are

identifiable although efforts have been relatively meager. Demonstrations of dental procedures within the school environment, for example, have provided initial dental experience to young children. In general, organized educational programs can contribute to the development of a patient who is psychologically prepared to seek and demand adequate dental services. Also, he is able to perceive the true value of dental care which is an essential service in contrast to the non-essential goods and services and the accompanying pressures exerted on his purchasing capacity.

SUMMARY

Although community dental health programs have been inadequate in number and scope, ample activity has taken place to demonstrate their worth. In addition to the primary objectives of decreasing the dental needs and increasing the dental services of the population, the community program contributes substantial benefits to the dentist, his practice, and his profession. Equitable apportionment of community responsibility and opportunities for assistance from State and Federal resources contribute to lightening the burden of the private dentist. Increased financial return and opportunities for broadening the scope of private practice are outgrowths of community programs. Ultimate benefits also include increased prestige and professional status. The full potential of organized community dental programs will be realized as soon as these programs become an established component in community health structure.

PROVISION OF DENTAL CARE IN COMMUNITY DENTAL PROGRAMS*

J. M. WISAN, D.D.S., M.S.P.H.**

A REVIEW of community dental care programs in the United States will reveal a wide variety of concepts, standards, procedures, and reports. Divergencies are not surprising, in view of the autonomy existing among local governments. However, two characteristics are found in nearly all community dental care programs:

1. Provision of services to children of low-income families.

2. Limitation of the extent and type of dental services provided.[1]

Neither sufficient funds nor adequate personnel are available for broad-scale programs for most communities. Analysis of the dental needs of children will indicate the necessity for restricting treatment programs. Nearly three hours of a dentist's time are necessary to provide initial care for the average child. This time does not permit specialized care, such as orthodontics.[2] Thus, a full-time dentist on duty 1,500 hours could treat only 500 children in one year. The cost per child, depending on the salary paid the dentist, would be at least $20.00 a year. Obviously, the cost of treating an

---

* Fourth in a series of papers prepared under the direction of the Committee on Community Dental Programs.

** Formerly Director, Division of Dental Health, Philadelphia Department of Public Health. Dr. Wisan passed away October 4, 1958.

appreciable number of children is prohibitive for most communities.

Because of the lack of funds and personnel, public health and welfare administrators, before establishing a dental care program, must consider such questions as:

1. What children should be treated?
2. What types of dental care should be provided?
3. What types of clinics should be established?
4. How can dental care programs be evaluated?

What children should be treated? Studies of the American Dental Association indicate that approximately 30 per cent of the American people visited the dentist in 1956. In Philadelphia[3] a study was made to determine the number of children from low-income homes who received dental treatment in community clinics. It was found that approximately 31 per cent visited dental clinics during the year. In other words, 80,000, or approximately 70 per cent, of the city's underprivileged children did not have any dental defects corrected during 1956.

Overawed by the great need of dental care, nurses, teachers, social workers, and volunteer health personnel do their utmost to include large numbers of children in community dental treatment programs. When administrators fall prey to this pressure for the inclusion of too many children in a dental care program, participating dentists provide incomplete and substandard treatment.

An effective method of limiting the extent of a community dental program without lowering standards is to limit the program to younger children. If the initial appropriation for a dental program is too small for including all children of low-income families, the administrator might start with six-year-old children. As more money is allotted, seven, eight, nine and ten-year-old children can be included.[4, 5]

A minimal program should include six to ten-year-old children for treatment of accumulated defects (all necessary extractions, fillings, and prophylaxis) and provide emergency treatment for other ages. What may be termed a well-developed program in the community would be one that included two to ten-year-old children for treatment of accumulated defects, and emergency treatment for other ages.

In both instances, communities would do well to institute programs in hospitals and in volunteer agencies to furnish dental care at minimum fees for older children. Provisions might be made to enable some agencies to defray the cost for treating older children unable to pay minimal fees. These agencies could provide types of treatment not included for the young children in the minimal care program, as suggested by the American Society of Dentistry for Children and by the Council on Dental Health of the American Dental Association.[6]

What types of dental care should be provided? It would seem that members of the American Society of Dentistry for Children would be particularly interested and helpful in developing standards by enunciating acceptable principles for treatment programs.

Primarily, public health administrators should be convinced that treatment should be limited to the extent that it can be done well.

Given a budget for a dental program, the administrator will estimate the cost of equipment and supplies. The amount allotted for dentists' salaries will, of course, determine the number of hours

that the dentists function. As previously stated, at least three hours per child will be necessary for initial care, which would include diagnosis, fillings, extractions, prophylaxis, and other incidental treatments. Endodontics, orthodontics, and prosthetics cannot be included in this time allotment. On the other hand, all of these types of treatment are furnished, and less than three hours per child are available, the number of completed cases will be low.

The writer has found it profitable to request the Council on Dental Health of the local Dental Society to designate not only the types of dentistry to be performed, but also standards for such dental care as is to be furnished.[7]

What types of clinics should be established? In cities and suburban communities with concentrated populations, the fixed clinic in a health center or a school building seems to be perferred by most dental administrators. Mobile clinics, in trailers or in trucks, are frequently used in rural and suburban communities.

Private offices have not been widely used. Nevertheless, the writer believes that their usefulness should be explored in communities where full-time dental clinics are unnecessary. Experience in New Jersey indicated that a private dental office program could be conducted at a reasonable cost. Private office programs can be instituted promptly and can be adequately supervised and administered.[8]

How can dental care programs be evaluated?

The efficacy of a dental care program can be evaluated by the following criteria:

1. What proportion of the population depending on the program is treated?
2. What percentage of the cases included in the program is completed?
3. To what degree have desirable standards of treatment been maintained?

To obtain the proportion of the population treated, it will, of course, be necessary to record the number of children treated during a given year by the agency evaluating its program, and the number treated by other agencies. Also, the number of children not able to obtain dental treatment in private offices is to be estimated. For example, in Philadelphia, it was estimated that in 1957 there were 124,000 children two to nineteen years of age whose parents could not pay private dental fees. The Philadelphia Health Department treated 15,928 children. In other words, approximately 30 per cent of the underprivileged children were furnished some dental treatment.

The number of children treated, of course, is only the partial story. How many of the cases were completed? In 1957, the Philadelphia Health Department clinic dentists reported 52 per cent of the cases completed (all necessary fillings and extractions provided). Unfortunately, many voluntary agencies find it impracticable and expensive to analyze data from dental clinic reports.

From a professional viewpoint qualitative analyses alone do not reveal the value of a dental care program.[9] Unless quality of services is maintained on a high level, both funds and time of personnel are wasted. It is difficult to objectively appraise all dental treatments. However, the quality of fillings can be fairly accurately appraised. The writer has utilized routine procedures for evaluating fillings by examining groups of treated children. A number of hypotheses have engendered this method of evaluation:

1. There is widespread indifference on

the part of many dentists toward proper cavity preparation in treating caries.[10]

2. Fillings, when improperly performed, may cause:
   a. Frequent replacements of fillings—waste of time and money
   b. Loss of teeth
   c. Disturbed occlusion
   d. Injured arch alignment
   e. Periodontal disturbances.
3. Fillings furnish fairly conclusive quantitative data.
4. Valid criteria can be designated for appraising quality of fillings (see Table 1).
5. Some features of cavity preparation can be judged after insertion of fillings.
6. Evaluation of fillings can be made in schools with minimum expenditure of time by conducting group examinations.
7. Routine evaluation of fillings when supported by in-service training will in most instances assure desirable operative dentistry.
8. Quantitative and qualitative evaluations minimize the intrusion of personal and partisan "politics."

The writer has been confronted with the criticism that he places too high a premium on fillings. Prosthetics, oral surgery, and rehabilitation have been glamorous appeals. Dentists assigned to filling teeth in a clinic frequently complain that they were placed in the "amalgam assembly line." They are unmindful of the fact that they are providing a basic and important health service.

I am reminded of a statement attrib-

TABLE 1

CRITERIA FOR APPRAISING QUALITY OF FILLINGS IN PERMANENT TEETH

	Outstanding	*Standard*	*Inferior*
Carving & Occlusion	Perfect adjustment and anatomy	Good occlusion and anatomy but no linear detail	Malocculsion or improper anatomy
Condensation	Perfect with high polish	Slight pitting with adequate polish	Definite pitting with no polish, tarnishing
Occlusal Outline	All fissures included	All fissures not included, but explorer does not stick in fissures not included	Explorer sticks in fissures not included
Occlusal Margin	Perfect	No catch, or insignificant catch	Definite catch
Interproximal: Outline	Perfect contour into embrasure	Contour acceptable Access to toothbrush	Contour unacceptable No access to toothbrush
Margin	Perfect	No catch, or insignificant catch	Definite catch
Contact	Perfect "billiard ball" contact	Broad and rounded contact	No contact or flat contact
Marginal Ridge	Correct height and perfect carving	Correct height and no carving	Incorrect height

uted to John W. Gardner, president of the Carnegie Corporation:

"The society which scorns excellence in plumbing because plumbing is a humble activity and tolerates shoddiness in philosophy because it is an exalted activity will have neither good plumbing nor good philosophy. Neither its pipes nor its theories will hold water."

BIBLIOGRAPHY

1. BLACKERBY, P. E., JR. Treatment in Public Health Dentistry, p. 209-210. In PELTON, W. J. and WISAN, J. M., Dentistry in Public Health. 1st Edition, Philadelphia and London, W. B. Saunders Company, 1949.
2. PELTON, W. J. Dental Needs and Resources, p. 78. In PELTON, W. J. and WISAN, J. M., Dentistry in Public Health. 2nd Edition, Philadelphia and London, W. B. Saunders Company, 1955.
3. Philadelphia Department of Public Health: Annual Statistical Report, 1956, p. 91. Philalelphia, the Department, p. 91, ,1956.
4. FINN, S. B., et al. Clinical Pedodontics. Philadelphia and London, W. B. Saunders Company, p. 16, 1957.
5. WISAN, J. M. What Are We Doing in Philadelphia? Public Health Views, Vol. 3, No. 1, Philadelphia Department of Public Health, p. 4-11.
6. American Dental Association. Dental Health Programs. Jan. 1, 1954, p. 17.
7. Philadelphia Department of Public Health. Standards for Dental Procedure. Bulletin of the Philadelphia County Dental Society, p. 112-113, 1954.
8. WISAN, J. M. State Dental Programs. In PELTON, W. J., and WISAN, J. M., Dentistry in Public Health. 1st Edition, Philadelphia and London, W. B. Saunders Company, 1949.
9. WISAN, J. M. A Guide for Selecting and Utilizing Indices for Evaluating a Program of Dental Care. In the Practice of Dental Public Health, University of Michigan School of Public Health, p. 151-153, 1956.
10. STIBBS, G. D. Cavity Preparation and Matrixes for Amalgam Restorations. J.A.D.A., 56:478, 1958.

NOTICE

The following recommendations will be made at our Annual Meeting, September 1959, at New York City:

1. Changing of Article III—Section 2 of the Constitution to read "Active membership in the Society shall be limited to members of the American Dental Association, the Canadian Dental Association, or any national dental association recognized by the A.D.A."

2. That the following deletion be made in Article IV—Section 1 of the Bylaws (Professional Relations Committee)—"to maintain a roster of approved clinicians on pedodontics and designate suitable clinical programs for state and local dental meetings which emphasize the practice of pedodontics."

LAWRENCE R. BURDGE, *Chairman*
Constitution and Bylaws Committee.

Unit News

Behold! . . . A novice follows a master. The outstanding job performed by Ted Levitas as Unit News Editor was such that this humble writer feels overwhelmed at the magnitude of the task ahead. However, every effort will be put forth to emulate the example set by Ted.

I was tremendously happy with the response of the Units to my first plea for news. It was terrific! Twenty-two responded. Many thanks for your cooperation. It makes my job easier. And now, without further ado . . . here is the news.

TINY KONIKOW

ARIZONA

Dr. LeSueur reports that the last meeting of the Arizona Unit was held in conjunction with the State Dental convention at Scottsdale on May 5. An all day clinic was held with Dr. Maury Massler as guest clinician.

The following are the new officers for the year:

President ..... Dr. J. G. Yount, Tempe
Vice-President .... Dr. W. S. Deeming, Tucson

CANADIAN SOCIETY OF DENTISTRY FOR CHILDREN

A hearty welcome to our Canadian friends who have for the first time sent in news of their Society.

Yours truly and wife were treated royally while in Toronto. Drs. Johnstone, Currie and Rapp acted as our hosts and gave us a most pleasant time. Many thanks to them.

And now for the news from across the border as reported by Dr. D. G. Johnstone:

"The Tenth Annual Convention of the Canadian Society of Dentistry for Children was held Saturday, May 9 at the Royal York Hotel, Toronto. The program opened at 9 A.M. with table clinics on subjects in the general field of dentistry for children presented by:

Dr. Ray H. Sawusch .... University of Michigan
Dr. Marvin Kozloz .... University of Illinois
Dr. Donald G. Woodside, University of Toronto
Dr. Herbert W. Sorenson ..... Toronto, Ont.
Dr. Elliott Siegel ..... Toronto, Ont.
Miss Patricia Prior, R.D.H. .. Hamilton, Ont.
Mrs. Pauline Borron, R.D.H. .. Hamilton, Ont.

Dr. D. G. Johnstone introduced the morning essayist, Dr. Z. Konikow of Royal Oak, Michigan, who spoke on "The Management of Pedodontic Problems."

A short business meeting concluded the morning session and officers were elected as follows:

Hon. Pres. .... D. G. Johnstone, Niagara Falls
President ..... D. R. Anderson, Toronto
President-Elect ..... P. E. Currie, London
Vice-Pres. and Sec.-Treas., C. D. Beierl, Toronto
Historian ..... D. L. Rife, Toronto

Registration total for the convention was 201. The majority of the members of our Society are from Ontario and most of them are engaged in the general practice of dentistry. This was the second convention of the Society since becoming a section of the Canadian Dental Association.

The two afternoon scientific presentations featured "Oral Manifestations of Systemic Disorders in Children" by Dr. M. Michael Cohen of Boston and Mr. Albert G. Richards, University of Michigan, who presented a paper on "Recent Advancements in Radiographic Techniques for Children." To geographically extend the activities of this Society, the Canadian Society of Dentistry for Children will meet at a place other than Toronto every other year. At these meetings a special ladies' program will be arranged.

Our 1960 meeting will be held on May 14, 1960 at the Hotel London, London, Ont. Dr. Kenneth A. Easlick of the University of Michigan is the main essayist and will speak on "Diagnosis." This meeting will have the support of the London and District Dental Society."

Many thanks for the news, Canadian friends. Keep the news coming. How about joining us in New York for the National meeting?

Southern California

Executive Secretary, Lorraine Duncan, passed on this news.

"Our last meeting was held June 8, 1959 and was the annual business meeting of the entire membership. Officers were elected as follows:

President ..... Dr. Wm. E. Allen, Pasadena
President-Elect .. Dr. Mario Fusco, Los Angeles
Secy.-Treas. .... Dr. John R. Kennedy, Reseda

Following the business meeting and dinner, one of our members, Dr. Clinton C. Emmerson, head of the Department of Pedodontics at the University of Southern California, spoke on "What's New in Pulpal Therapy for Primary Teeth." The Department of Pedodontics at University of Southern California has been doing histological investigations of various pulpal therapy techniques and this lecture was in the nature of a preliminary report.

Our Program Committee is lining up speakers for meetings starting in the Fall. There are seven meetings scheduled, starting on September 28. Included in these is the annual clinic meeting with our members as clinicians, and the ninth annual Post Graduate Conference in the Spring.

Attendance at meetings during the past year averaged 112, and as usual, the greatest number (150) attended the Clinic meeting. A membership drive was conducted last Spring, at which time a letter explaining the activities of the Unit and the advantages of membership in the Society was sent to all non-members in Southern California. Eighty new applications for membership were received." Nice going, Southern Cal.

Connecticut

This fine report was received from Elias N. Fass.

"The year 1959 has seen the Connecticut Unit approach the 200 member mark. With this phenomenal growth in membership has come an inspiring increase in interest on the part of the membership. Study groups have been organized throughout key areas of the State and their work is to be presented

in representative table clinics at the National meeting in New York in September. They will be given by the New Haven and Norwalk study groups.

A two day seminar on Children's Dentistry was presented by Dr. Ralph McDonald to a group of over 70 members, who came away very impressed by the excellence and scope of the presentation.

New officers of the Society are as follows:

President ..... Elias N. Fass, Fairfield
President-Elect ..... Albert Sasso, Waterbury
Secy.-Treas .. Naomi A. Dunn, New Britain

This organization is proud of its team of Eichenbaum and Dunn. Dr. Irving Eichenbaum is now president of the Connecticut State Dental Association, a richly deserved honor, while Naomi, his wife, has worked long, faithfully, excellently and tirelessly as Secretary-Treasurer of our organization, a shining example of devotion to a cause—the betterment of Pedodontics."

Idaho

Wes Young has this to say.

"The Idaho Society of Dentistry for Children held their fourth annual meeting at McCall, Idaho on June 21. The scientific program on "Preventive Orthodontics" was presented by members of the Spokane Pedodontic Study Club. The presentation provided practical tips in this area that were of value to all of the members. An informal cocktail hour and dinner dance on Saturday evening preceded the scientific sessions on Sunday morning.

At the business meeting Sunday afternoon, the following officers were installed:

President ..... Dr. Frank Hyke, Lewiston
President-Elect .... Dr. Jack Mauk, Pocatello
Secretary-Treasurer, Dr. Wesley O. Young, Boise

The Idaho Unit voted to offer to cosponsor the Pacific Northwest Conference on Children's Dentistry at McCall in September 1960."

Georgia

From way down Georgia way comes this news from William Shupert.

"The Georgia Unit has one big seminar program each year. Our last program was held last Fall and we are looking forward to another one this October. We sent out an announcement of this meeting and enclosed an application for membership about three weeks ago. To date, we have received dues from eight new members bringing our membership to 81.

Our slate of officers for the year is as follows:

President ..... Dr. Thorwald Eros, Atlanta
President-Elect .... Dr. John Wallace, Atlanta
Secy.-Treas. .... Dr. Wm. R. Shupert, Atlanta

We plan to have an outstanding speaker at our annual clinic with several short clinic presentations by our own members."

Illinois

As Ted Levitas would say—Jane Selbe has done it again and sent us this fine report:

"Well, our two day seminar program in April held at the Wagon Wheel Lodge is but a pleasant memory. Over 30 members, most of them with their spouses took away some very worthwhile ideas and enjoyed themselves in the process. Stan Korf and Bill Sowle lined up such a good program that the Wagon Wheel's many other entertainments almost lost out. Still, everyone managed to

enjoy the relaxed atmosphere and to snatch some recreation, too.

Dr. Quinton Williams flew in from Corpus Christi, Texas to tell us how they use "Cast Silver Inlays" in the SECOND largest State of the Union. Dr. Reuben Balagot of the University of Illinois (subbing for Max Sadove) told us about "Anesthesia and Medication in Dentistry for Children." After listing agents and methods presently being used, he described with deceiving cheerfulness the dangers which can accompany their use.

Dr. Edward Lis, professor of Pediatrics at the University of Illinois, College of Medicine, gave us some new outlooks on the handicapped child. At the close of the first day's program, the members adjourned to demonstrate their agility in the swimming pool, or on the ice rink and bowling lanes. A cocktail hour brought all back together.

Dr. Milton Braun, professor of Orthodontics, St. Louis School of Dentistry, brought with him enough material to lecture for three days and managed to squeeze most of it into one half day. Each member received a folder full of information on the reading and analyzing of cephalometrics and on the development of occlusion. All in all, the program was "super" and Bert Gilbert, president, deserves a pat on the back.

This takes care our Unit 'til September when we converge on New York for the National meet. Stan Korf is already buzzing with plans for the October meeting to be held in Chicago. We have had so many new "recruits" this year, it keeps Ronny Rothenberg busy taking in dues and sending out cards. It looks like a good year for dentists AND kids in Illinois!"

Iowa

Ronald B. Hufford gives us a short report as follows:

"At the last meeting, Dr. William E. Brown, of the department of Pedodontics at the University of Michigan, was the speaker of the day. His topic was "Tooth Eruption, Normal and Otherwise, Mixed Dentition Analysis, Diagnosis and Treatment and Space Maintenance."

It was voted to have a booth at the State meeting to represent the Iowa Unit and manned by members.

The following officers were elected for the year:

President ..... Dr. Merle Bean, Des Moines
President-Elect .. Dr. A. Miles Olson, Laurens
Secy.-Treas. .. Dr. Ronald B. Hufford, W. Des Moines

Next annual meeting will be the first or second Monday in April 1960. We have a very active group and expect a great deal of interest among the dentists in our district."

Massachusetts

Welcome to our midst, Mel Gulbrandsen. Your first report is excellent. Keep the news coming. Here is Mel's report:

"The last meeting of the Unit was the annual one held May 5 in conjunction with the Massachusetts Dental Society meeting. Luncheon was enjoyed at the Red Coach Grille in Boston followed by a short business meeting at which time officers were elected.

Our Unit has chosen the theme of "The Dentist's Role in Dental Health Education" for the year. Each of our three meetings will be directed in that channel and we hope to have a table clinic or panel on "Growth and Development" presented. The last meeting we

The accompanying photo shows our Executive Council poring over plans for our next year. From left to right: Bob Diamond, Mel Gulbrandsen, Leif Johannessen, Lou Calisti.

hope to make a social affair. Probably will hold it at some resort in the western part of the State so that our "brothers" in that locale will feel they are a part of our Society. Most of our membership as well as the meetings are in the greater Boston area."

MICHIGAN

Past President Bill Graetz of the Michigan Unit reports they have just finished another busy year. Here is what Bill has to say.

"One of the highlights of our busy year was the drive for new members which was conducted under the leadership of Secretary-Treasurer Konikow. "Tiny" saw to it that every member in the State Dental Association, the Dental Hygienists Association and every senior dental student in the Universities of Michigan and Detroit received a letter citing the aims of the Society and the benefits to be derived from being a member. The letter included a schedule of meetings with an invitation to attend. An application for membership was also enclosed. As a result of this campaign, "Tiny" and his "Gal Friday" were kept busy sending out membership cards and data to 72 new members. We were mighty proud!

Another "feather in our cap" was the Annual meeting in Grand Rapids which was in conjunction with the State meeting, April 22-24. It was held for the express purpose of giving recognition to the Hygienists who as Associate members have been very active in our Unit. We were also happy to honor Dr. Wm. E. Brown, president-elect of the American Society of Dentistry for Children and Mrs. Helen Garvey, president of the American Dental Hygienists Association. We are proud to have these two fine people chosen from our State to serve. Congrats to both! As out-going president, it was my pleasant duty to turn the gavel over to Dr. Z. Konikow who has been a tower. . . . I should say "giant" (have you ever seen him?) of strength to our Unit. "Tiny" was our Secretary-Treasurer for two terms and did a terrific job.

Under his leadership, I know the Unit will go on to bigger and better things!"

A large group of Michiganders is planning to converge on New York City in September.

The Michigan Unit received the following from Helen M. Garvey, President of the American Dental Hygienists Association and it was so aptly put, we

think you might like to read her sentiments too.

> "Each being dedicated to the purpose of improving the dental health of children, the Michigan Society of Dentistry for Children and the Michigan State Dental Hygienists Association naturally have been brought into frequent contact. This contact has been broadened by dedicated members in each group, into a close cooperation which might well set a pattern for activities among all health organizations particularly interested in the promotion of better dental health for children."

A letter from Elizabeth Quinn, president of the Michigan State Dental Hygienists Association expressed thanks for the recognition their Association received at the Annual meeting saying in part: "We are grateful to have been included in such an outstanding program and proud to be associated with such a fine group as the Michigan Society of Dentistry for Children."

New Jersey

Election of officers was held at the last business meeting and the following were elected:

President .. Dr. Robert D. Moyer, East Orange
Pres.-Elect .. Dr. H. Curtis Hester, Glen Ridge
Sec.-Treas. .. Dr. Robert E. Brenner, Elizabeth

An all day seminar is being planned for February 1960.

North Carolina

Here is the news as reported by Roy Lindahl for the North Carolina Unit. . . .

"The North Carolina Unit is looking with anticipation to its first annual two day seminar to be held in Charlotte, November 6 and 7. The featured clinician will be Dr. Cecil Bliss of Sioux City, Iowa. He will present his views on "Practice Management" with a slant toward Dentistry for Children. Dr. Bliss has a national reputation in this area of interest and we are proud to have him on the program.

During the two day meeting, officers for the ensuing year will be installed at a short business meeting, along with some "bull" sessions and social activities.

Dr. Horace Reeves of Charlotte is the local arrangements chairman and is doing a great job.

Members of the Demeritt Pedodontic Study Club will present a group table clinic at the national meeting in New York and the Unit is very pleased to have such fine representation for this all important meeting.

In closing this report, we would like to extend an open invitation to all members of ASDC to share with us in the program at Charlotte."

Montana

The Montana Unit held its annual meeting at East Glacier Lodge in East Glacier, June 26-28.

Dr. Frank J. McAtee gave a very fine clinic on "Preventive Orthodontics and Tooth Guidance." Everyone gained some very worthwhile information and had an enjoyable stay at the hotel in spite of bad weather.

The following new officers were elected:

President ..... Dr. L. E. Hall, Missoula
Vice-Pres. ..... Dr. P. M. Feda, Wolf Point
Secy.-Treas. .. Dr. Fred R. Schwin, Red Lodge

Yellowstone National Park has been selected as the site for the annual meeting in 1960.

Nebraska

Here is an interesting report from Don Stormberg—

"Our last meeting was our annual business meeting on April 29, 1959 and was held at the same time as the Nebraska State Dental Society meeting. Our officers are as follows:

President, Dr. W. S. Kramer, University of Nebraska, College of Dentistry
Pres.-Elect ..... Dr. L. W. Teutsch, Omaha
Secy.-Treas. .... Dr. D. H. Stormberg, Omaha

We presented the four Nebraska winners of the ASDC award for excellence in scholarship and interest in Dentistry for Children to: Clarence Lippenstrew, Hildreth, Nebraska, and Wm. M. Zigg, Des Moines, Iowa both from the University of Nebraska and to: Don Pape, Boise, Idaho and Wm. Killoy, Butte, Montana from Creighton University, Omaha.

Dr. Ralph Ireland, Dean of Nebraska Dental College, presented a short inspiring talk on "The First Seventeen Years of Pedodontics." He was congratulated by the Nebraska Society of Dentistry for Children on his recent appointment as Dean of the College of Dentistry. Dr. Ireland was formerly head of the Department of Pedodontics.

The executive council met and planned our Fall meeting for October 18 and 19. It will be a two day meeting in Omaha at the new Town House Hotel. The first day will be a social get-together in the morning and registration, and table clinics in the afternoon. The second day will be a lecture program, presented by "The Fleege Brothers" of Seattle and Milwaukee. This will be one of Nebraska's most attractive programs. Housing accommodations may be arranged for at the Town House and members are welcome to bring their wives for this occasion."

New Mexico

I. L. Voda sent his news as follows:

"About the only news I have is that three of the four elected officers of the New Mexico Dental Association are members of the American Society of Dentistry for Children, namely, Dr. Alfred Lopez of Albuquerque, president; Dr. Wm. Blueher, Albuquerque, secretary-treasurer; and Dr. I. L. Voda, Las Vegas, vice-president.

On July 29 we will have a full day demonstration and clinic by the Rocky Mountain folks of Denver which will be held in Albuquerque. This program is not limited to members of the New Mexico Unit but has been extended to all dentists in the State."

Oregon

The June meeting of the Oregon Unit was held jointly with the Portland chapter of the American Pediatric Society. Dr. Joseph Matarazzo, clinical psychologist of the University of Oregon Medical School, was the principal speaker. The presence of the members' wives made the meeting a complete success. Officers elected at the June meeting were: Dr. Evelyn M. Strange, president, Dr. Robert H. Anderson, president-elect, Dr. Marian de Stoppelaar, secretary-treasurer, Dr. T. R. Norman, publicity.

The Oregon Unit is planning a full schedule of meetings for October, November, January, February, April and May. It is hoped that Oregon's popular young Governor Mark Hatfield will be the opening speaker in October.

Under the leadership of Dr. Daniel F. Haselnus, past president of the Oregon Unit, plans for Children's Dental Health

Week are being formulated and coordinated with all component societies in Oregon.

With the 4th Annual Pacific Northwest Conference of ASDC at Harrison Hot Springs in British Columbia getting us off to a good start, the Oregon Unit is looking forward to a busy and fruitful year.

Pennsylvania

The last meeting of the Pennsylvania Unit was held at Bedford Springs Hotel, May 16. It was a three day conference which included scientific demonstrations with clinicians, table clinics and lectures. Dr. Roy M. Wolff was the main speaker and spoke on "Child Management and Business Administration." The social events were capped by a banquet held Saturday evening at which we were honored by the presence of Dr. and Mrs. Harold K. Addelston, president of the American Society of Dentistry for Children. An election of officers resulted in the following being selected:

President .. Dr. Morton E. Winkler, Pittsburgh
Secy.-Treas., Dr. Benjamin Grossman, Philadelphia

The Unit's next meeting will be held in the Fall and is a business meeting.

New York

Walt Woods' report verbatim gives us an idea of what we are in for at the ASDC meeting.

"FABULOUS! Yes, that is the word for the National meeting in September. If you miss this you are going to be sorry. Joel Freedman is another Billy Rose when it comes to planning. He has the whole show ready to start Friday, September 11 with the Knickerbocker Welcome Party at 4 P.M. Come early and stay late, the drinks and laughs are FREE. The weekend is star-studded with social activities such as the UN tour, fashion show and, of course, Fifth Avenue shopping. The little woman won't want to miss this. In case this isn't enough, perhaps past national president, Hugh Keenan and his arrangements committee can fix up something for you! Our whole slate of New York officers will be on hand to assist. Arnold Rosenberg, our new president, promises to take care of all traffic tickets, theatre passes and extra-curricular activities. President-Elect Roland Hawes of "Kodak City" promises the finest photography coverage ever. Charles Beck, our former "work horse" secretary-treasurer, and now V.P. wants you to know the scientific program arranged by Sidney Kronfeld is TOPS. Yours truly, Walt Woods, new secretary-treasurer, will be on hand until the Farewell "Aloha" Party doing important things like putting extra olives in your Martini glass.

You know the National is so terrific, we don't even have definite plans for a Fall get-together. It will be an anti-climax by comparison.

Our wonderful ASDC president, Harold Addelston, holds the key to New York City. Won't you join us in the greatest production of ASDC ever?"

Sounds like everything has been thought of to make the National meeting *the* Greatest!

Oklahoma

No news from this Unit except to say that the new officers are:

President ..... John E. Lewis, Oklahoma City
Secy.-Treas. .. E. W. Foster, Jr. Oklahoma City

Virginia

Charlie Vincent reports:

"Our last meeting was held just prior

to the Virginia State Dental Association meeting at the Hotel Roanoke on April 8. Dr. Roy Lindahl, Professor of the Department of Pedodontics at the University of North Carolina, presented a talk on "Pedodontics in the General Practice." An election of officers was held and the following were elected to serve for the coming year:

President ..... Dr. Luke Pillis, Lynchburg
Pres.-Elect ..... Dr. Bernard Brann, Leesburg
Secy.-Treas. .. Dr. Chas. J. Vincent, Richmond

The Unit's project at the moment is the preparation and printing of informative folders, "Your Child and Better Dental Health" which deal with carbohydrate intake and caries control. They have met with great success and our second printing has been completely sold out. These folders are made available to members of the Virginia Society of Dentistry for Children at cost." Good work, Virginia Unit—keep it up!

Wisconsin

Fred Druse has the following news to report:

The Spring meeting was held April 26. Dr. Robert E. Moyers of the University of Michigan contributed to the success of this meeting with his presentation of "Orthodontics for the Non-Orthodontist." Election of officers resulted in the selection of:

President .. Dr. Leland Crosby, Stevens Point
Pres.-Elect ..... Dr. James Helz, Milwaukee
Secy.-Treas. ... Dr. Fred A. Druše, Wauwatosa

Wisconsin Rapids is the site of our Fall meeting on October 12.

Invitation

The Pan American Council of Dentistry for Children will hold its Third Congress November 22-29, 1959, in Bogota, Colombia, South America.

The Executive Committee for the Congress cordially invites members of the American Society of Dentistry for Children to attend and to present scientific papers. Arrangements can be made to have submitted papers presented to the Congress if the writer himself cannot attend. Please inquire for further details of

President Benjamin Gomez Herrera
Carrera 13, No. 41-58
Bogota,
Colombia, S. America.

Announcement

A course on Dentistry for Handicapped Children will be presented at the University of Pennsylvania by Dr. Manuel M. Album and Associates 30th November; 1st and 2nd December 1959. It is arranged to give the practitioner a better understanding of the dental problems and treatment of children who suffer from cerebral palsy, mental retardation, muscular dystrophy, multiple sclerosis, and other handicapping conditions.

For further information, please write to Postgraduate Courses, School of Dentistry, University of Pennsylvania, 4001 Spruce Street, Philadelphia 4, Pennsylvania.

Commentary

By this time you have all received an official program of the American Society of Dentistry for Children meeting in New York. It is necessary to register for the clinics as soon as possible. Many are already closed and others are filling up rapidly. In addition to all the wonderful things Walt Woods has to say of the New York meeting, I would like to send along a few remarks. I feel a great big

"thank you" is due M. Joel Freedman, general chairman of the national meeting for the tremendous job he and his Committee have done in setting up the scientific programs and arranging the social events. They have thought of everything—nothing has been spared.

Our ladies will have the time of their lives. Something has been planned for them for nearly every minute of the day. There will be door prizes at every function, including an oil painting by a famous artist. We understand the Brunch and Fashion Show at the Waldorf-Astoria will surpass all others ever held there!

You won't want to miss this fabulous time in New York! Send in your reservations NOW.

Just a reminder from Jim Simmons, vice-president of the ASDC, that there will be meetings of all Unit secretaries in Room 103, Commodore Hotel, on September 12 and 13 at 11:00 A.M.

Material intended for Unit News should be sent to Tiny Konikow, 500 S. Washington Avenue, Royal Oak, Michigan. Fourth Quarter deadline is October 25.

The Acrylic Mouthpiece for Poliomyelitis and Cerebral Palsy Patients

ROBERT R. BUCKLEY, D.D.S.*

INTRODUCTION

THE Cerebral Palsy Clinic of Indiana University Medical Center has developed an acrylic mouthpiece[1, 2] during the past four years which enables severely involved patients to indulge in self help activities. Mouthpieces in the past have been quite varied taking the form of sticks, plastic plates, rubber molds, pencils, paint brushes, etc. without much consideration of dental complications. Dentists have known for years that objects held between the front teeth cause uneven wear and abrasion[1, 2] and permit posterior teeth to continue to erupt—thus opening the bite.[3]

Four years of study have resulted in an improved method of construction of the mouthpiece and greater satisfaction to the patient.

The previous study reported in the JOURNAL OF DENTISTRY FOR CHILDREN, Sept., 1957, was limited to athetoid cerebral palsy patients with severe involvement of the extremities. The mouthpiece was designed to aid in typing and operation of wheel chairs. It was also used to hold a straw for children with feeding problems. The present study has been expanded to include polio patients (bulbar type) with complete paralysis of 4 extremities and the technique of construction has been simplified.

The mouthpiece is made from methyl methacrylate in one piece. It covers the clinical crowns of all the teeth and has an anterior extension which holds a straw, pencil, or other object according to its use. The extension is directed approximately 45° with the horizontal.

METHOD

1. Excellent alginate impressions and a wax bite of the teeth in centric occlusion are taken at the first appointment for study models.

2. Trim white stone models of the teeth in centric relationship using the wax bite as a guide. The posterior surface of the models should be flat and in the same plane; the posterior—lateral surfaces should also be trimmed in the same plane as illustrated. (Fig. 1) The white stone study models can be duplicated with hydrocolloid to provide a superb working model in Vel-Mix and at the same time eliminate the need for a second impression.

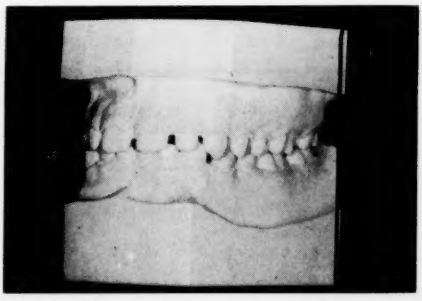

FIGURE 1

3. Adapt trays of Dentsply Trubase Baseplate material to cover the clinical crowns of all the teeth. Undercuts are

* Cerebral Palsy Clinic, Indiana University Medical Center, Indianapolis 7, Indiana.

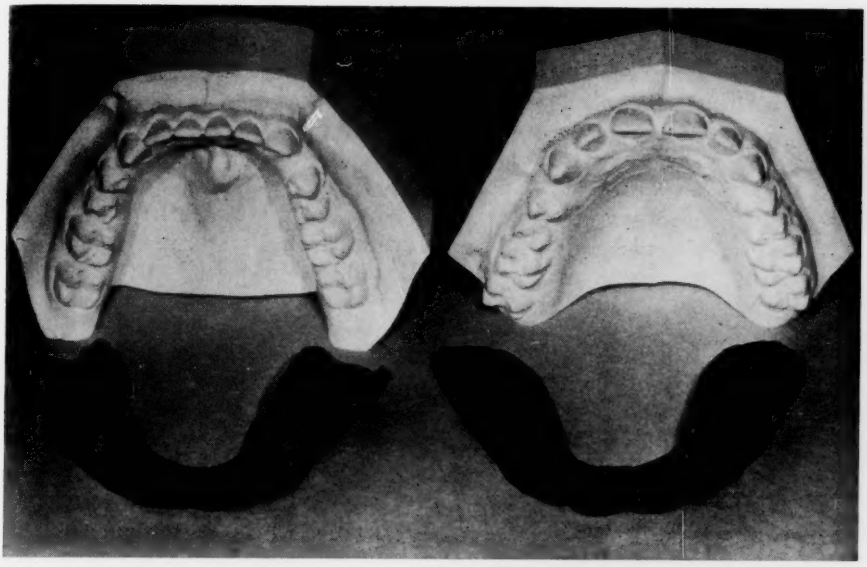

FIGURE 2a

eliminated and the trays are freely removable. (Fig. 2)

4. Line up models, trimmed to centric occlusion—on a flat surface and measure their width.

5. Line up the models again with trays in position and bring the models together paralleling posterior and lateral surfaces. Record the width of the models and reduce the thickness of the trays until the separation of the models is less than 1.0 mm.

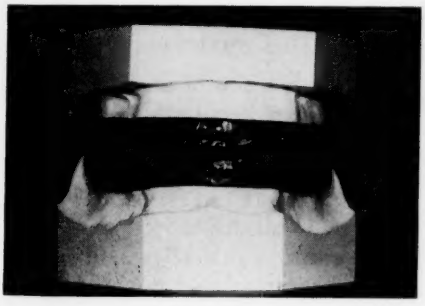

FIGURE 2b

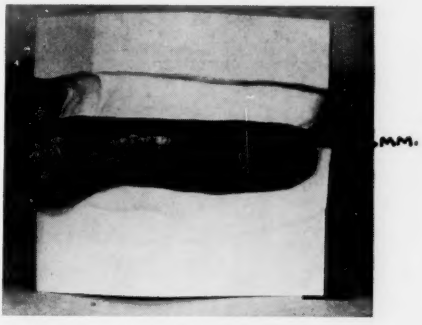

FIGURE 3

6. When the vertical dimension has been corrected to less than 1.0 mm, seal the trays together with wax and form the mouthpiece in wax to the desired contour. (Fig. 3)

7. The anterior extension should be approximately 45° with the horizontal. However, the cant of the occlusal plane is variable and must be considered if the patient is to experience a comfortable typing position with the end of the

typing stick approximately 14 inches from the eyes.

8. The wax model of the mouthpiece should be invested in plaster or stone with a separating medium between the two halves of the flask. After 1 hour place the flask in boiling water 4 minutes and remove the wax.

9. Pack the plaster models with heat cure acrylic and process as a regular denture.

10. Remove the processed mouthpiece from the flask and polish to a high luster. Eliminate any undercuts to permit easy removal of the mouthpiece from the working models.

11. With an acrylic bur place a hole in the extension of the mouthpiece to fit a plastic straw or stick.

12. The finished mouthpiece should not separate the posterior teeth more than 1.0 mm. (Fig. 4)

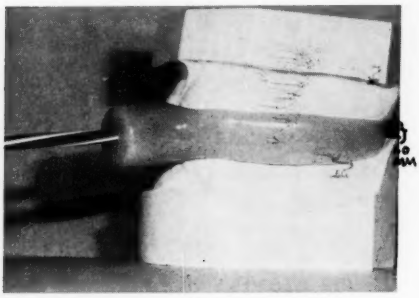

FIGURE 4

DISCUSSION

When properly constructed the mouthpiece should lie within the interocclusal space permitting the patient to retain it in the mouth for long periods of time without discomfort. The bulk of the mouthpiece should be reduced posteriorly to eliminate gagging but should at all times cover the clinical crowns of all the teeth. The increased width of the mouthpiece in the molar area provides sufficient retention to hold it in position.

One must consider eruption of the permanent teeth and allow room for them to erupt into the mouthpiece by removing acrylic in the critical areas. As the arch lengthens and 1st and 2nd permanent molars erupt, new mouthpieces should be constructed.

The angle of the extension of the mouthpiece varies with the occlusal plane of the individual. Consequently it becomes desirable to have a wax try-in of the mouthpiece. However, it is possible to place the extension in a fairly desirable position and place the hole in the extension of the finished mouthpiece while the patient is present. The end result should be that the patient is in a comfortable typing position with the head erect. The occupational therapist is invaluable at this phase of treatment. When the occlusal plane is too steep, the eyes of the patient are strained to see the tip of the stick which is 14″ from the eyes on an average. The head should be in a reasonably erect position while typing. This encourages patients to use posterior neck muscles and to gain control of movements of the head and neck. The size of the extension should remain as small as possible to permit the patient to get his lips around it.

CONCLUSION

The construction of a plastic mouthpiece has been described using centrically articulated unmounted models of the teeth. The mouthpiece has been used by a group of 14 cerebral palsy patients and 3 polio quadriplegics, and 2 spinal injury quadriplegics. (Figs. 5, 6) The patients are able to hold this mouthpiece in the mouth for several hours and can

FIGURE 5

remove and insert the mouthpiece without help. Some patients use the mouthpiece to type and operate battery driven wheel chairs for periods of 8 hours or longer. For them the mouthpiece is an integral part of their person and enables them to achieve some degree of independence.

Definite improvement in swallowing has been noted among patients who use this device to drink and the patient-feeding time has been reduced dramatically. The mouthpiece aids in reducing tongue thrust. To date we have not experienced any undersirable effects and there has been no unusual increase in caries among the individuals using the mouthpiece. For patients who require mouthpieces to type as well as operate wheelchairs, it is simpler to construct a second mouthpiece than to interchange pencils or sticks.

FIGURE 6

BIBLIOGRAPHY

1. BUCKLEY, R. R. and SLOMINSKI, A. H. The acrylic mouthpiece, The Am. J. Occup. Ther. 1:23-25, Jan.-Feb., 1958.
2. BUCKLEY, R. R. Mouthpieces for the handicapped. J. D. Child. 24:174-179, 3rd Q., 1957.
3. HEMLEY, SAMUEL. Bite plates, their application and 1938.

Measurements of the Primary Teeth

WILLIAM S. KRAMER,* D.D.S., M.S., AND RALPH L. IRELAND,** D.D.S., M.S.

INTRODUCTION

THIS investigation was concerned with the anatomical and morphological details of the primary teeth. Rather lengthy descriptions of the primary teeth are available to the profession[1, 2, 3] but these descriptions lack effectiveness because a complete set of average measurements cannot be given for each tooth.

For many years teachers of dental anatomy have been handicapped in presenting their material to students because of the limited number of measurements available for the primary teeth. The morphometric descriptions of the primary dentition have been, therefore, somewhat nebulous and evasive. The student, in attempting to carve reproductions of each type of tooth, has been frustrated by his inability to satisfy himself as to the accuracy of his effort because definite figures were not available with which he could check. Especially is this true of the posterior primary teeth. The lack of a definite guide prevents understanding and comprehension on the part of the student who is seeking to familiarize himself with the anatomical features of these teeth.

SURVEY OF THE LITERATURE

Each of the various authors[1, 2, 3, 4, 5, 6] of texts of Dental Anatomy presents a table of measurements for the primary teeth. In every case this table refers to the original measurements as given by G. V. Black.[5] This table of measurements presented by Black[5] and passed along from year to year by other authors has been the only guide for use by dental students. Only seven different measurements are given for each tooth. It has long been realized that these few measurements are inadequate for any scientific evaluation of the dimensions and morphology of the teeth for they provide insufficient detail for discerning anatomical analysis.

Black, in arriving at his averages, gave no indication of the number of specimens studied. He merely says, "In the following tables the results of the measurement of many teeth of each denomination are given. The numbers measured for the different varieties differed, but in all denominations they were sufficient to insure reasonable accuracy as to the average size."

METHODS AND MATERIALS

It was first necessary to determine which measurements should be made in order to gain as complete a representation of each tooth as possible. It was decided, therefore, that each measurement should be made from one definitely locatable and describable anatomical point to another such point. Certain of the proposed measurements, however, had to be abandoned after measuring began when it was found that the above conditions could not be followed consistently.

Outline sketches of each type of tooth were made viewing the tooth from the buccal, lingual, mesial and distal aspects.

* Professor and Chairman Department of Pedodontics, University of Nebraska College of Dentistry, Lincoln, Nebraska.

** Dean and Professor of Pedodontics, University of Nebraska, College of Dentistry, Lincoln, Nebraska.

Portions to be measured were selected and colored lines were drawn from point to point and numbered to represent each individual measurement. Different colored lines were used on each aspect of the sketch, each such line representing a measurement to be taken for that particular type of tooth. A set of sketches was made in this manner for each denomination of tooth. It was possible, then, for the person measuring to determine by a glance at these sketches just which portions of the tooth were to be measured and recorded. Some 45 measurements were made for each posterior tooth, and more than 1,600 posterior teeth were measured.

All measuring was done using the sketches and a numbered key as a guide. The tabulations were recorded by an assistant on a chart containing a column for each colored number representing a measurement to be made. Naturally, because of destruction or mutilation from various causes or because certain portions were missing or altered, all measurements were not obtainable from each specimen tooth. A dash was placed in the appropriate column of the score sheet when any particular measurement could not be obtained. Each measureable feature of each tooth was recorded in the expectation of gaining sufficient information from each part to represent an average which would be significant. There are, therefore, some determinations which have been accumulated in greater numbers than others. The missing measurements, incidentally, provide an interesting sidelight to this study because, in certain instances, one could speculate as to those surfaces of the teeth which are more susceptible to caries than other surfaces. Other information provided by the frequency of missing measurements indicates which roots are sometimes fused, and the relative frequency of occurrence of other anatomic abnormalities.

Measurements of the teeth were made by means of a Boley millimeter gauge which had been altered by sharpening the parallel beaks to a point to facilitate accurate placement. This gauge permits accurate reading to the tenth of a millimeter. The parallel beaks were used for calibrations whenever possible because the contrast of the various curvatures of the tooth with the straight edge helped to make close discrimination possible.

Root length was measured in a plane parallel with the long axis of the tooth. This method was used because it was believed it offered less chance for error than if the axis for each root were estimated, especially when the root exhibited some curvatures. Some roots with extreme curvatures were not measured.

Results

The results of this investigation are most conveniently presented in tabular form. Table A indicates the information obtained for the maxillary molars with a brief description of each measurement, the number of measurements made, and the average in millimeters for each measurement. Figure I portrays these average measurements in more graphic fashion by representing them on an outline drawing of the maxillary first molar as viewed from various aspects. The outline drawings and various average measurements for the maxillary second molar are given in Figure II.

Table B gives a brief description of each measurement, the number of measurements made, and the average in millimeters for each measurement for the mandibular molars. The outline draw-

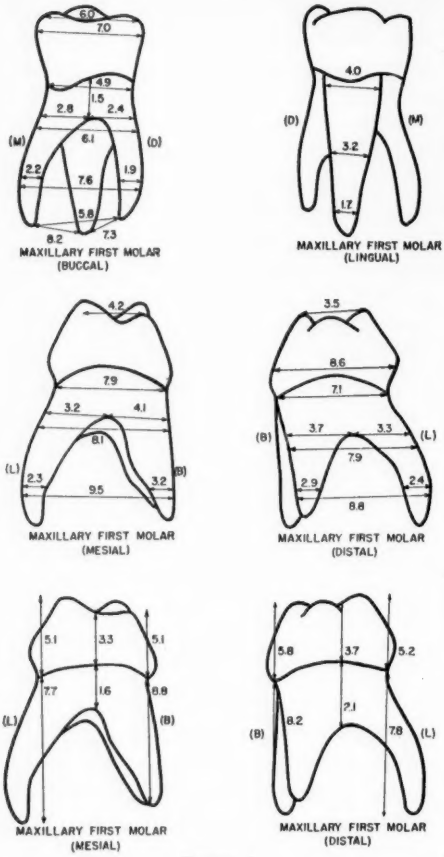

FIGURE 1

ings having representations of each of the various measurements are given in Figure III for the mandibular first molar and in Figure IV for the mandibular second molar.

Table C contains the information dedermined for the anterior teeth.

STATISTIC EVALUATION

A statistical evaluation was made for each of the measurements of each of the anterior teeth, a maxillary molar and a mandibular molar. The mean root square deviation was calculated for each of these measurements, as was the range which was expressed as a percentage. The values obtained were then analyzed as to their statistical significance and the following conclusions were reached. Incidentally, these results indicate that, since the mean root square deviation falls within normal limits for all except the root measurements of the posterior teeth, the investigation need not have been performed so vigorously, for similar results within this range of values would have been obtained with a considerably smaller sample.

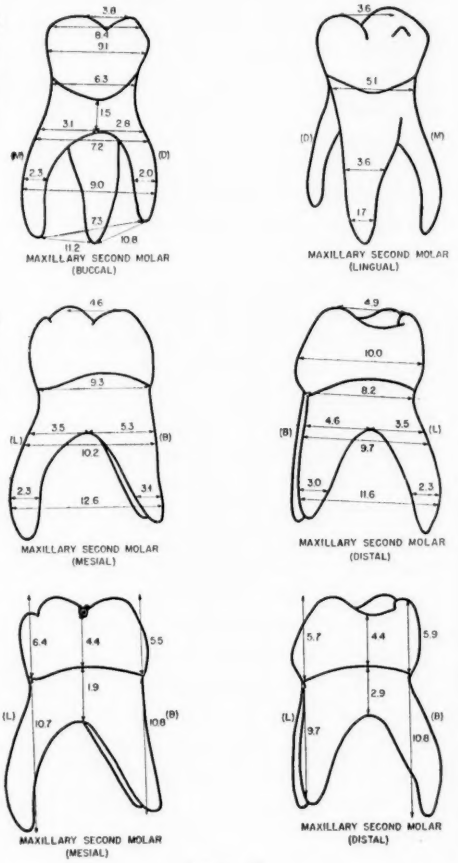

FIGURE 2

1. δ and the range for the measurements were investigated.
2. $\frac{\delta}{\bar{x}}$ was calculated.
3. It was found that $\left(\frac{\delta}{\bar{x}}\right) \sim .06$ for anterior teeth and increased as one went posteriorly to the molar teeth to $\left(\frac{\delta}{\bar{x}}\right) \sim .08$.
4. The increase of $\left(\frac{\delta}{\bar{x}}\right)$ as one goes posteriorly is mainly due to the increase of $\frac{\delta}{\bar{x}}$ for the root measurements of the molars.
5. Freaks, or anomalies, increased in frequency as the tooth sample for the posterior teeth was analyzed.
6. This inconsistency is exhibited in the range observed in the samples investigated.
7. The range increased for the posterior teeth, especially for the root measurements.

δ—the mean root square deviation

$\bar{x}$—the average obtained for each measurement

$\sim$—nearly equals

$\left(\frac{\delta}{\bar{x}}\right)$—the average of the mean root

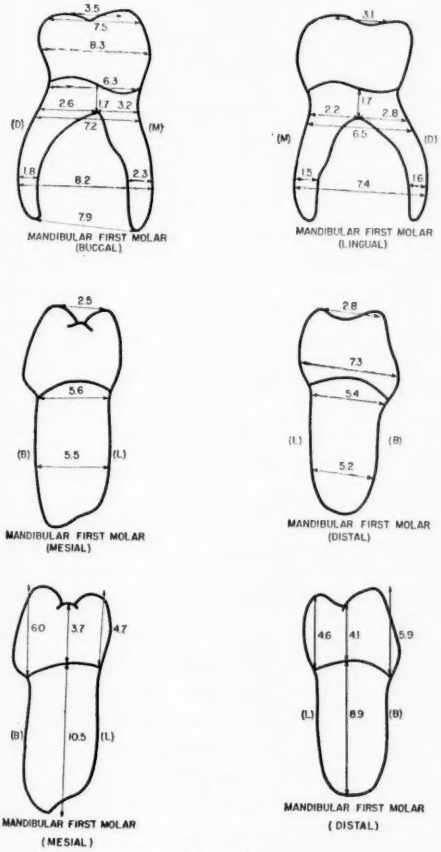
MANDIBULAR FIRST MOLAR (BUCCAL)
MANDIBULAR FIRST MOLAR (LINGUAL)
MANDIBULAR FIRST MOLAR (MESIAL)
MANDIBULAR FIRST MOLAR (DISTAL)
MANDIBULAR FIRST MOLAR (MESIAL)
MANDIBULAR FIRST MOLAR (DISTAL)

FIGURE 3

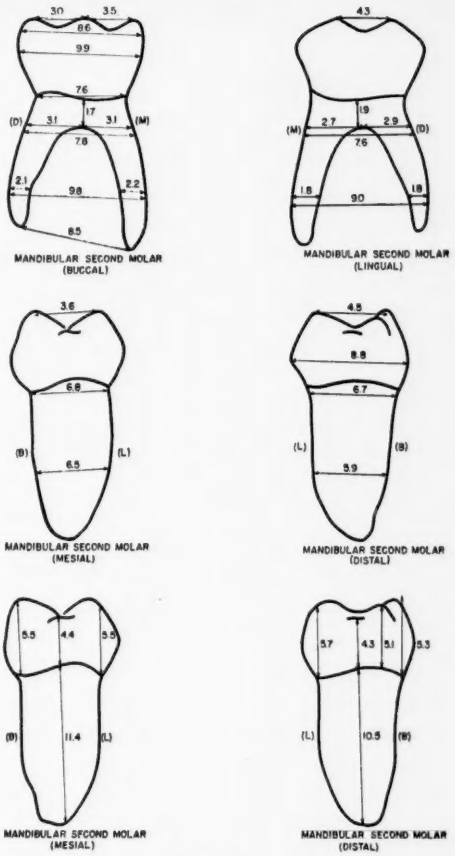
MANDIBULAR SECOND MOLAR (BUCCAL)
MANDIBULAR SECOND MOLAR (LINGUAL)
MANDIBULAR SECOND MOLAR (MESIAL)
MANDIBULAR SECOND MOLAR (DISTAL)
MANDIBULAR SECOND MOLAR (MESIAL)
MANDIBULAR SECOND MOLAR (DISTAL)

FIGURE 4

TABLE A
MOLARS

Maxillary Second		*Description of Measurements*	*Maxillary First*	
AVERAGE IN MMS.	NUMBER OF MEASUREMENTS		AVERAGE IN MMS.	NUMBER OF MEASUREMENTS
5.07	583	Greatest mesial distal width of lingual root	4.0	552
3.64	481	Mesial distal width of lingual root at middle portion	3.18	467
1.70	308	Mesial distal width of lingual root at apical portion	1.71	198
4.64	508	Apex of mesial lingual cusp to apex of mesial buccal cusp	4.18	355
3.47	511	Buccal lingual width of lingual root at level of bifurcation of lingual root and mesial buccal root	3.23	411
5.34	571	Buccal lingual width of mesial buccal root at level of bifurcation of lingual and mesial buccal roots	4.13	566
10.21	508	From lingual surface of lingual root to buccal surface of mesial buccal root at level of bifurcation	8.12	422
2.33	366	Buccal lingual width of lingual root at level of greatest spread	2.32	248
3.96	382	Buccal lingual width of mesial buccal root at level of greatest spread	3.22	321
12.56	397	From lingual surface of lingual root to buccal surface of mesial buccal root at level of greatest spread	9.54	345
4.93	495	Apex of distal buccal cusp to apex of distal lingual cusp	3.46	166
4.58	443	Buccal lingual width of distal buccal root at level of bifurcation of distal buccal and lingual roots	3.74	298
3.49	508	Buccal lingual width of lingual root at level of bifurcation of distal buccal root and lingual root	3.27	303
9.68	382	From buccal of distal buccal root to lingual root at level of bifurcation	7.95	211
2.97	206	Buccal lingual width of distal buccal root at level of greatest spread	2.88	159
2.34	295	Buccal lingual width of lingual root at level greatest spread	2.38	166
11.57	187	From buccal of distal buccal root to lingual of lingual root of greatest spread	8.82	187
10.00	637	Greatest buccal lingual width of crown	8.63	602
8.23	652	Buccal lingual width at cervix, distal aspect	7.06	602
9.29	582	Buccal lingual width at cervix, mesial aspect	7.86	428
5.47	652	Cervical line to apex of mesial buccal cusp	5.06	524
4.39	357	Cervical line to mesial marginal ridge	3.31	524
6.39	582	Cervical line to apex of mesial lingual cusp	5.11	515
1.89	460	Cervical line to bifurcation of mesial buccal root and lingual root	1.58	422

TABLE A (Continued)
MOLARS

Maxillary First		*Description of Measurements*	*Maxillary Second*	
AVERAGE IN MMS.	NUMBER OF MEASUREMENTS		AVERAGE IN MMS.	NUMBER OF MEASUREMENTS
10.76	411	Cervical line to apex of mesial buccal root	8.83	388
10.74	277	Cervical line to apex of lingual root	7.68	148
5.75	613	Cervical line to apex of distal buccal cusp	5.82	397
4.45	508	Cervical line to distal marginal ridge	3.72	240
5.88	566	Cervical line to apex of distal lingual cusp	5.24	422
2.87	413	Cervical line to bifurcation of distal buccal root and lingual root	2.13	198
9.71	168	Cervical line to apex of distal buccal root	8.16	172
10.78	277	Cervical line to apex of apex of distal lingual root	7.84	168

square deviation divided by the average for each measurement.

Discussion

Certain of the measurement averages obtained in this study may be compared directly with those as given by Black. In many cases the differences are quite small. In certain instances, there is considerable variation. The most notable of these variations will be mentioned. In the case of the maxillary second molar the measurement of length over-all obtained by Black exceeded by 1.3 mm. the measurement obtained in this study. The average for the mesial-distal diameter of the crown in these figures exceeds Black's calibration by 0.8 mm. Considering the maxillary first molar, the greatest variation noted is in the length of the mesio-buccal root, Black's average being greater by 1.2 mm. This difference is also reflected in length over-all. The remainder of the averages were relatively close.

With reference to the mandibular first molar, the greatest variation with Black was found in the length of root where the average of this study proved to be 0.7 mm. greater for the mesio-buccal root, and the mesio-distal diameter of the crown which was 0.57 mm. greater in this study. Turning to the mandibular second molar, the most noticeable disparity occurs in the figures expressed for over-all length. This average was found to be 2 mm. shorter in this study. Observation of Black's figures reveals that root length plus crown length, if added, would total 16.8, a figure more nearly in harmony with the findings of this study. It is difficult to understand how Black's averages can reconcile an over-all length calculation of 18.8 while presenting a root length and crown length which total two millimeters less. Comparisons for the anterior teeth can be more conveniently made by referring directly to Table C.

In addition to the comparisons with Black's averages, certain other observations can be made from these data. For one thing, the actual average spread of the roots is indicated, a point previously not known, and therefore in controversy among dental anatomists. Another interesting item is revealed by the missing measurements, when one notes the number of times the calibration from marginal ridge to cervical line was un-

TABLE B

MOLARS

Mandibular First AVERAGE IN MMS.	NUMBER OF MEASUREMENTS	*Description of Measurements*	*Mandibular Second* AVERAGE IN MMS.	NUMBER OF MEASUREMENTS
		Apex of distal cusp to apex of distal buccal cusp	2.96	247
3.50	90	Apex of distal buccal cusp to apex of mesial buccal cusp	3.49	198
7.50	153	Mesial distal width of crown at marginal ridges	8.62	166
8.27	219	Greatest mesial distal width of crown	9.96	290
6.27	588	Mesial distal width of crown at cervix	7.65	543
1.66	90	Buccal surface from cervical line to bifurcation of mesial root and distal root	1.73	408
2.59	544	Mesial distal width of distal root at level of bifurcation	3.13	522
3.17	544	From distal of distal root to mesial of mesial root at level of bifurcation	3.06	522
7.17	90	Mesial distal width of mesial root at level of bifurcation	7.85	405
1.82	333	Mesial distal width of distal root at level of greatest spread	2.09	474
2.26	544	Mesial distal width of mesial root at level of greatest spread	2.21	474
8.21	153	From distal of distal root to mesial of mesial root at level of greatest spread of roots	9.77	503
7.93	182	Apex of mesial root to apex of distal root	8.55	363
3.10	68	Apex of mesial lingual cusp to apex of distal lingual cusp	4.30	221
1.70	153	Lingual surface from cervical line to bifurcation of mesial root and distal root	1.87	394
2.18	544	Mesial distal width of mesial root at level of bifurcation	2.72	503
2.84	544	Mesial distal width of distal root at level of bifurcation	2.94	494
650	90	From mesial of mesial root to distal of distal root at level of bifurcation	7.57	388
1.48	483	Mesial distal width of mesial root at level of greatest spread	1.85	437
1.64	333	Mesial distal width of distal root at level of greatest spread	1.76	411
7.38	333	From mesial of mesial root to distal of distal root at level of greatest spread	9.03	455
4.65	397	Cervical line to apex of distal lingual cusp	5.69	437
4.07	218	Cervical line to distal marginal ridge	4.35	425
		Cervical line to apex of distal cusp	5.13	388
5.90	512	Cervical line to apex of distal buccal cusp	5.34	266
8.94	211	Cervical line to apex of distal root	10.55	390
5.96	512	Cervical line to mesial marginal ridge	5.51	390
3.73	572	Cervical line to distal marginal ridge	4.38	266
4.74	422	Cervical line to apex of mesial lingual cusp	5.52	388
10.50	247	Cervical line to apex of mesial root	11.37	436

TABLE B (Continued)

MOLARS

Mandibular First		*Description of Measurements*	*Mandibular Second*	
AVERAGE IN MMS.	NUMBER OF MEASUREMENTS		AVERAGE IN MMS.	NUMBER OF MEASUREMENTS
2.80	66	Apex of distal lingual cusp to apex of distal buccal cusp	4.55	211
7.32	572	Greatest buccal lingual width of crown	8.77	441
5.39	544	Buccal lingual width of crown at cervix	6.68	543
5.24	422	Buccal lingual width of distal root in middle portion	5.88	472
2.50	66	Apex of mesial buccal cusp to apex of mesial lingual cusp	3.56	211
5.58	544	Buccal lingual width of crown at cervix	6.78	512
5.45	544	Buccal lingual width of mesial root in middle portion	6.52	472

obtainable on the mesial and distal surfaces of the various molar teeth. Restoration with metal, or destruction by caries accounts for the differences in ability to obtain this measurement and is evidence pointing to the proximal surface of each tooth which is the more susceptible to caries. It was noted that the missing measurement most frequently occurred on the distal surfaces of the first molars and the mesial surfaces of the second molars. Such a situation lends credence to our present concept of caries occurring in sheltered, protected areas which are inaccessible to the cleansing action of mastication and toothbrushing.

Some knowledge of the resorptive pattern of the roots of the primary teeth may also be gained from this study. In the case of the second maxillary molar, the differences in the number of measurements obtained would suggest that the disto-buccal root is first to resorb, followed by the lingual root, and finally the mesio-buccal root. Interpretation of this material for the maxillary first molar indicates that the lingual and distal roots, or their fused roots, begin resorption earlier than the mesio-buccal root. Inspection of the data for the mandibular molars reveals that the distal root begins resorption before the mesial root.

The measurements selected to be made for the anterior teeth coincided with those chosen by Black. Because of the difficulty in obtaining good specimens, particularly those with intact roots, the measurements of the roots are insufficient to warrant drawing definite conclusions. It is interesting to note the closeness of correlation between the averages of the anterior teeth as found in this study and those advanced by Black.

Throughout this study, results were compared with those averages presented by Black, previously our only source of information in this regard. In general, there is a fair correlation in those measurements which are comparable. The individual variations, while seemingly minor, in the aggregate will be found to produce discernible differences in the appearance of the tooth. This is most noteworthy where teeth are being carved to dimension in the study of dental anat-

TABLE C
ANTERIORS

	Maxillary					
	Cuspid		*Lateral*		*Central*	
Description	AVERAGE IN MMS.	NUMBER MEASURED	AVERAGE IN MMS.	NUMBER MEASURED	AVERAGE IN MMS.	NUMBER MEASURED
Length over-all	18.87	18	14.96	11	16.45	19
Length of crown	6.03	217	5.58	196	6.04	212
Length of root	12.84	27	10.2	15	10.32	24
Mesio-distal diameter of crown	6.82	123	5.10	185	6.55	206
Mesio-distal diameter at cervix	4.90	197	3.68	178	4.56	200
Labio-lingual diameter of crown	6.88	185	4.76	196	5.00	212
Labio-lingual diameter at cervix	5.41	197	3.65	183	4.12	205
	Mandibular					
Length over-all	16.75	21	15.21	11	13.87	9
Length of crown	5.92	186	5.23	177	4.92	151
Length of root	10.83	28	9.90	13	8.86	12
Mesio-distal diameter of crown	5.18	193	4.08	157	4.28	137
Mesio-distal diameter of cervix	3.77	188	3.12	173	3.11	146
Labio-lingual diameter of crown	4.96	202	4.12	177	4.17	151
Labio-lingual diameter at cervix	4.20	188	3.56	151	3.62	139

omy by the student. Inasmuch as these carvings are frequently made three or six times natural size, these individual variations stand out with some importance as the visual representation is gained by the student.

Summary

Because measurements were made, except where noted, parallel with or at right angles to the long axis of the tooth, it is possible for anyone utilizing these figures to apply them more accurately to anatomical study. Blocking out the outlines of the tooth preparatory to carving or drawing may be more conveniently accomplished by having figures available which were obtained in this geometric fashion.

The detailed measurements made for the posterior teeth, with particular reference to root form and spread, along with individual cusp position and height, should facilitate exactness in the anatomical reproduction of these teeth. While it is true that frequent morphological variations occur in addition to considerable variation in size, a standard or an average concept of each type of tooth is of value to student and practitioner alike. It is in this respect that average dimensions are most valuable.

The teaching of dental technics and methods of operation presupposes an

average type of tooth from the standpoint of instrument design, instrumentation, and operative procedures. If the practitioner has the normal or average situation well in mind, he can more readily compensate for or adapt to the atypical situation when it presents.

BIBLIOGRAPHY

1. Zeiss, R. C. and Nuckolls, James. Dental Anatomy, St. Louis, Mo., C. V. Mosby Co., 1949, Vol. I, p. 458.
2. Wheeler, Russel C. Textbook of Dental Anatomy and Physiology, Philadelphia, Pa., W. B. Saunders Co., 1942.
3. Diamond, Moses. Dental Anatomy, New York, The Macmillan Co., 1952, Third Edition.
4. Stillson, W. C. Dental Anatomy, Philadelphia, Pa., W. B. Saunders Co., 1929.
5. Black, G. V. Descriptive Anatomy of the Human Teeth, Philadelphia, Pa., The S. S. White Manufacturing Co., 1902, Fourth Edition, p. 14.
6. Hogeboom, F. E. Practical Pedodontia, St. Louis, Mo. C. V. Mosby Co., 1953.

Pharyngeal Occlusion in a Child Relieved By Dental Appliances—A Clinical Report*

R. C. Haskins, D.D.S., M.S.D.**

THIS is a report of a child having recurrent respiratory obstruction and difficulty in deglutition since birth. She was evaluated and treated from 3 5/12 years of age to 5 years of age by an interdisciplinary professional team.† A unique method of dental therapy led to improvement in the patient's problem.

Clinical Summary

The patient, a white female, was born at estimated 8 months gestation of a pregnancy complicated by continued vaginal bleeding for the first 2 months, a severe prolapse of the uterus at approximately 4½ months, rupture of fetal membranes at approximately 6½ months and, although the mother was bed-fast for the remainder of the pregnancy, the leakage of amniotic fluid continued until delivery. Labor was brief and normal. There was no record of the time interval between birth and the first breath. During the first several postnatal hours oxygen supplementation was required and the infant did not cry. By reason of inability to suckle and swallow, the first one and one-half months of life were spent in the hospital. Dropper feeding was instituted in the hospital and continued for six months. After the first six months she was fed by a bottle having a widely-perforated nipple. Later in this first year she transferred spontaneously to cup feeding. From six months of life to approximately the twelfth month, she had recurrent episodes of respiratory obstruction, cyanosis and limpness. General growth and nutritional state were poor until twelve months of age.

Subsequently, she has been able to ingest food more satisfactorily and has become consistently moderately obese. At the time of her diagnostic hospital studies (age 3 5/12 years), she was able to chew meats and other solid foods; however, she did not attempt to swallow these chewed masses. Choking was noted at mealtime, although she had no episodes of aspiration and neither has she had pneumonia. She had marked nocturnal respiratory difficulty, associated with a gurgling sound, similar to that which has been reported in literature concerning this problem.[1] Pediatric studies gave no evidence of cardiac or abnormal pulmonary disability. At the time of this examination, speech was limited to two or three words, comparable to that of a 12-month old child.[2] She commonly substituted grimaces or head and body gestures for words.

Hospital Course

An electroencephalogram was attempted, for which the child was sedated with chloral hydrate, in standard dosage for her age. This mild sedation resulted in

* This work was aided by a grant from the U. S. Public Health Service.

** Department of Pediatrics, University of Utah College of Medicine, 1940 South Second East, Salt Lake City 15, Utah.

† Participating in this group with the author were James F. Bosma, M.D., Professor of Pediatrics; Samuel G. Fletcher, Ph.D. and Ralph L. Shelton, Jr., M.S., Research Fellows in the Department of Pediatrics.

respiratory difficulty with cyanosis and the patient was urgently admitted to the hospital for oxygen therapy. Initial observations of this study were made at that time.

She was generally obese; skin demonstrated no abnormalities; head appeared small and her face narrow; mandible appeared to be either smaller than usual or retruded and the tongue was small and inactive. A persistent moderate cervical lordosis was evident. There were no abnormalities of thorax and abdomen or of extremities.

Some of the cranial and facial angles of measurement as employed by Steiner[3] were studied from a lateral headplate roentgenogram of this child made by another health service at 2 6/12 years of age and were judged to be within normal limits. The mandible appeared to be of normal size. The relationship of the mandible to maxilla in this earliest roentgenogram was similar to the relationship existing in films made when the child was studied by our group. The roentgenogram made at 2 6/12 years illustrated a distal positioning of the mandibular teeth as related to the maxillary teeth, which means that a Class II relationship existed. The same relationship existed at 3 6/12 years of age when the child was examined by our team.

By manual manipulation it was found that breathing was easier if the mandible was held in a position ventrad to its usual resting position. For this reason, an apparatus was desired that would easily hold the mandible and the structures it supports in a more ventral position.

The patient was held in her crib and, despite resistive efforts, impressions were made of her mouth, using an alginate impression material. Warm water was used to accelerate the setting time and care was taken in the seating of the impression tray not to force any of the excess material into the pharynx. Models were made for study purposes.

The mandibular dental model was articulated with the maxillary model in the patient's rest position (Figure 1).

FIGURE 1. Before treatment. Note the pronounced maxillary overjet and the relation of mandibular molars to maxillary molars.

If a device could be fabricated to bring the mandible to a Class I position while the patient was at rest, it would seem that the mandible could then allow the oral contents to remain in a position ventrad to that which it presented, thus helping to keep the pharynx patent.

Dental Therapy

Castings for the cuspid teeth were fabricated on the stone models. As a trial effort, wax crowns were carved to cover the stone models of the maxillary cuspids and first primary molars and the man-

dibular cuspids. The maxillary crowns on either side were then waxed together so that each maxillary complement could be cast as a single unit. After the wax-up of the crowns was completed, inclined planes were waxed to the linguals of the maxillary crowns. The inclined planes were carved so they would begin at the distal occlusal of the first primary molars and would terminate at the mesiogingival of the cuspids. Also, hooks were waxed to the buccal of the cuspid crowns, to afford intermaxillary linkage with elastic bands* when desirable. The wax-up was made so that when the mandible approached the maxilla, the mandibular cuspid crowns would strike the maxillary inclined planes and mechanically slide the mandible to a ventral position. This, it was hoped, would help effect a pharyngeal patency, hence allow the airway to remain open.

The wax patterns were cast in gold, finished and cemented to the teeth.

After these "appliances" were cemented, the patient was observed carefully for any fretfulness possibly indicating that her bite may have been opened beyond the tolerance of the free-way space.[4] No restrictions were imposed upon eating or drinking. The patient seemed to be comfortable and made no attempt to dislodge the appliances. Her mother commented that the child slept better the night her appliances were seated than she ever had before. Steady improvement in freedom of respiration was noted following the cementation of the trial appliances and twenty-four hours later the patient was discharged from the hospital. The parents were instructed to have the child wear the intermaxillary elastics at night because it was during these hours that her breathing problem was greater.

At the end of seven weeks use of the trial appliances, it was decided to fabricate a simpler appliance. Compound impressions were made and gold crowns with buccal hooks were cast for the mandibular second primary molars. The purpose of the hooks was to allow intermaxillary linkage with the maxillary cuspids. This device allowed better traction when the elastics were in place (Figure 2). The parents were again advised to have the patient wear the elastic bands during night sleep.

FIGURE 2. Models of the patient's mouth showing the appliances used during the major period of treatment.

After the second appliances were worn for 20 months, they were removed and the dentition and occlusion were evaluated. The mandible had moved one cusp ventrally to place the teeth into a more normal occlusal relationship (Fig-

* S. S. White small elastic ligatures.

ure 3). The appliances were not replaced. Ingestion was so much improved that solids could be chewed and swallowed.

From the time of placement of the crowns until this writing, the patient has had reasonable comfort and no respiratory obstruction has been reported.

FIGURE 3. After treatment. The mandible has moved to a more ventral position. Note the relationship of the second primary molars.

Speech development was rapid during the period in which the dental appliances were used. When the patient was first examined by the speech pathologists her vocabulary was the extent one would expect of a 1-year-old child (she was capable of expressing only two or three words). At the end of one year of using the dental appliances, she was able to express many words which were on the two and three-year level and she was using short sentences.[2] With this information we can, then, conclude that her language growth was greatly facilitated.

A lateral roentgenogram made one month after the appliances were removed indicates some return of the mandible to its original dorsal positioning; however, at the time of this writing, the occlusion does not appear to be changing.

DISCUSSION

The clinical problem of this child is comparable to that found in infants with Pierre Robin syndrome,[5] glossoptosis,[2] and gonadal dysgenesis.[6] Apparently hypoxia and feeding difficulties arising as a result of the tongue mass being forced into the pharynx by the retruded mandible.

By use of intraoral appliances the mandible was brought ventrad and, along with an inadvertently opened bite, the oral cavity was enlarged in which the tongue could function better and the pharynx was no longer occluded.

The mandible was held in a ventrad and caudad position by the described applicances until enough growth and development of the mandible and its stabilizing elements[7] could occur, to allow uninterrupted air passage. Even with the mandible again becoming retrodisplaced, the pharynx will be large enough to maintain a patent airway.

With the recent advances that have been made in the use of anesthesia in dentistry,[8] one may wonder why this patient was not given a general anesthetic and standard crown preparations and accurate castings made for her teeth instead of using those fabricated from a comparatively inaccurate model. This would have been preferable, but after the surprising degree of depression, thus cyanosis incident to sedation, the team

felt a general anesthetic would be inadvisable.

Another problem incident to fabrication of the appliances was to make the dental castings of such a nature that the bite was not opened in excess of the free-way space. Had the free-way space been exceeded there may have been a strain on the muscles and much patient discomfort and an attempt at rejection of the treatment may have followed.[4]

One should be ever mindful of the problem of dental caries and employ the necessary steps through proper nutrition, oral cleanliness and dental services to cope with this condition. Because this child offered much resistance to dentistry she did not receive our recommended dental treatment. For this reason, it is the opinion of the writer that in an effort to avoid such problems total dental care should be arranged for the patient not only during treatment of this type, but as early as is possible before therapy as well as after therapy.

It would seem that the immediate relief of the respiration problem and the exceptional abruptness with which the patient's speech development progressed, indicate a sound means of treatment, although it is difficult to mark as a sound procedure a method based on only one case history.

Summary

At three and one-half year old white female with a history of respiratory and feeding difficulties was presented for study and treatment. Medical examinations, dental examinations, speech evaluations and laboratory studies were made and correlated.

Cardiac and pulmonary diseases were ruled out as a cause of her hypoxia. It was determined that intermittent pharyngeal occlusion was the cause of the respiratory problem. The investigators felt that retrodisplacement of the mandible caused oral structures to be forced into the pharynx and hence cause an occlusion of the airway.

A dental appliance using intermaxillary linkage was fabricated to help hold the mandible in a ventral position (Figure 2), such that the pharynx would remain patent.

By the end of a 20-month period speech and deglutition were improved and the mandible had grown downward and forward sufficiently to allow the pharynx to continually remain patent without any outside interference.

Acknowledgments

The author wishes to thank Dr. Garth Myers of the Utah State Health Department for his help with the early history of this patient; Dr. O. R. Smith, of Brigham City, Utah, for the patient's interim medical care; and Dr. William Crockett, of Salt Lake City, for his aid with the radiographic studies.

References

1. Bartelheimer, H. Uber Glossoptosis. Kinderarztlice Praxis, 7(2):53-56, February 1936.
2. Carmichael, L., in McCarthy, D. Manual of Child Psychology, 2d edit., Manual of Child Psychology, John Wiley and Son, Inc., 1954, pp. 542, 221.
3. Steiner, C. C. Cephalometrics for You and Me. Am. J. Orthod., 39:729-755, October 1953.
4. Thompson, J. R. Rest Postion of the Mandible and Its Significance to Dental Science, J.A.D.A., 33:151-180, February 1946.
5. Robin, P. Glossoptosis Due to Atresia and Hypertrophy of the Mandible. Am. J. Dis. Children, 48:541-548, 1934.
6. Richart, R., and Behirschke, K. Gonadal dysgenesis in a newborn infant. New England J. Med., 258:974-978, May 15, 1958.
7. Weinman, J. P., and Sicher, H. S. Bone and Bones, Fundamentals of Bone Biology (2nd edition), St. Louis, The C. V. Mosby Company, 1955.
8. Brown, E., and Kopel, H. M. Procedure of General Anesthesia for Operative Dentistry. J. Dent. for Children, 22:184-187 (4th Quarter), 1955.

EDITOR'S NOTE:

The American Dental Association is 100 years old in 1959. The accompanying reprint was taken from the Dental Cosmos of August 1849. In the century passed, improvements in materials and technics have been accomplished, but the concern and consideration for the young patient suggested by Dr. Pierce, is still the indication of true professional regard for the welfare of children. We are indebted to Manny Album for submission of this article.

A.E.S.

The Preservation of Deciduous Teeth

In offering a few suggestions to the profession on the preservation of deciduous teeth, I trust it will not be out of place to preface them with some remarks respecting the temptations which beset the operator in performing his duty in this particular branch of practice.

There is no class of patients with whom the dentist meets, where he finds it more difficult to operate than upon children, when decay from constitutional or other causes has attacked the teeth. They are not old enough themselves to understand the importance of preserving them; and generally, parents or guardians are too heedless or ignorant to appreciate the future comfort of the child. The operator has no one to aid him in performing this difficult duty; hence, the temptation to operate quickly, with the least trouble, and in accordance with the wishes of the ignorant, by extracting the offending organ, without first using proper means for its preservation.

It is to the young practitioner particularly that I address these remarks, and I ask that, in justice to himself, and in justice to his young patients, he will hesitate before acting hastily and adverse to the best interests of children. He must remember, that in offering his professional services to the public, he incurs an obligation to discharge a duty which requires more than a mere temporary relief from pain: he has a duty to perform for the future health and development of human beings.

I know the plea is often urged that parents are unwilling to give a compensating fee for filling and other operations upon the deciduous teeth. Such, in many instances, is the case: but even these would be fewer if the dentist, thoroughly understanding the importance of it himself, would take the opportunity and trouble to explain to them the evils resulting from the premature loss of these teeth. If such a course fails to produce the desired effect, then do your duty to the little sufferer, and let the consciousness of having done so be your temporary reward, and a more permanent one will be sure to follow, in the increase of your practice, from the fact that your conduct is gaining the confidence of an intelligent public.

In this paper I shall not attempt to speak of interrupted dentition, its cause, and cure, but confine myself to a few general remarks on points essential to a healthy eruption of the teeth, the proper means of preserving them, and the evils arising from their premature loss. In securing the first

of these, there is no one thing that does more toward it, and is more easily attended to, than properly cleansing the mouth; though this of itself will not suffice, yet with it the risk of a tedious eruption and imperfect teeth is greatly lessened. In order to attain this end, the mouth from early infancy should be kept pure and clean, which may be done by regularly washing it previous to the eruption of the teeth, commencing as soon as practicable, and continuing as often at least as once a day for eighteen or twenty months, or until we have the eruption of the deciduous teeth completed. After this, the use of a small soft brush twice a day is desirable, being careful to have the teeth perfectly free from and impurities, or food that may become impure, before putting the child to sleep for the night: the reason for this precaution is so apparent, that it will not be necessary to mention it.

With this course we have cleanliness secured, and the battle is half fought. Next to this, have the teeth frequently and carefully examined, and on the first appearance of decay, remove it. If the cavity is sufficiently large to receive a solid filling of gold, or Hill's stopping (Ed. note: a form of gutta percha), put it in; if only superficial, polish the surface with pulverized pumice or spar. This is the course I would have dentists advise their patients to pursue, or have pursued, with their children; but, unfortunately for the child, the dentist is seldom consulted until the decay has progressed so far, that suffering has ensued, either from exposure of the nerve, a severe spell of periostitis, or alveolar abscess and its accompanying results. It is then that the dentist is called upon, with positive instructions to extract the tooth. Here arises the temptation for injudicious treatment, and it is with the view of staying this reckless kind of practice, that I am induced to offer a few suggestions upon this subject.

Let us first consider the course to be pursued where the dental pulp, being apparently healthy, though deprived of its natural protection by decay, is subject to irritation from the contact of foreign substances. With the child comes to us the complaint that pain is experienced in attempting to eat, which is relieved by cleansing the teeth, but again ensues when eating is resumed. The plan to be pursued under such circumstances is, to carefully cleanse the cavity, taking care not to let the instrument come in contact with the exposed pulp, for in so doing, the child experiences pain, and is unwilling to have you proceed further; but with care you may avoid this, and complete your operation. After cleansing the cavity, dry it as well as practicable with cotton or spunk (I prefer this to paper; it is less harsh, hence, less liable to produce pain); then place in your paste, such as you use in ordinary cases for destroying the nerve, and there make it secure by placing over it cotton moistened with gum sandarac varnish, being careful not to force it down on the pulp, which would cause much unnecessary pain. In placing the paste in the tooth, abandon the small pledget of cotton or lint, which is generally used in getting it from the bottle, and take instead a small excavator, and carry it to the tooth with this instrument. In doing this, two advantages arise: first, we have not the unnecessary quantity of creosote taken into the mouth—an excess of which

is liable to come in contact with the tongue or mucous membrane, cauterizing and destroying portions of it. The second advantage is, that we have more room for the cotton and varnish, which is intended to secure the paste and protect the mouth from its destructive effects. This should remain in the tooth from twelve to twenty hours, in proportion to the age and health of the child, and the density and development of the tooth. As to the exact time it should be left in each individual tooth, no positive directions can be given; each operator must use his judgment, and be governed by surrounding conditions at the time; but that it can be left much longer in some mouths than others, without injuring the teeth, there can be no doubt.

On the return of your patient, your course is the same as in ordinary nerve cases, care being as necessary in these as in the permanent teeth. Those who have filled deciduous teeth are aware of the difficulties attending the operation, and of the impossibility of putting as much pressure upon them as the permanent ones; but of this there is little need, for the teeth, when in this condition, have, in the majority of cases, only to be preserved from two to four years, so that an ordinarily solid gold filling will readily last that long, and if Hill's stopping be used, but little pressure is necessary. One thing, however, is essential, and that is patience on the part of the operator. Without you have a good share of this, it is hardly worth your while to attempt to operate for children of any growth.

In using the Hill's stopping, adhere to the long established custom of filling the pulp cavity with gold, moistening the first piece with creosote; which precaution will do much toward lessening the probability of periosteal inflammation of alveolar abscess following the operation. I am aware there is much prejudice exiating against the use of arsenic, or any arsenical preparation being applied to the deciduous teeth, on the ground of injuring the permanent ones lying so immediately behind them. Such evil results I have never witnessed, nor do I see how they could occur, where proper care was taken in its use. If the objection is based upon the ill use of it in the hands of unskilled practitioners, the same could be urged to its use in any form, and for any purpose.

In considering the course to be pursued where the child, when placed in our hands, is suffering with periostitis or alveolar abscess, we have several things to be observed: 1st. Will it be *weeks, months,* or *years* before the propable eruption of the permanent tooth, which is to occupy the place of the offending organ? If we can decide, without doubt, that it will be but a few weeks at most, it is advisable to extract it at once. If it will, however, be months, and probably years, then another course is desirable, unless the disease is of such a nature as not to yield to palliative treatment, and the continuance of it is likely to injure permanently the surrounding tissue. Of this, however, we can soldem judge, without first making the effort to correct the evil, by the use of various remedies we have at our command, such as lancing, leeching, and cold applications to the gums; also, such disinfecting agents to the pulp cavity of the tooth as creosote, or spirits of camphor, etc. In pursuing

this treatment we may retain those teeth for months; and even though the child should occasionally suffer some pain, it were better so, than that the tooth should be extracted so long before the permanent one is ready to take its place.

In preparing this paper, it is not my purpose to mark out a system of practice to be pursued indiscriminately, but to urge upon my fellow members of the profession the necessity of employing every means within their reach to prevent the premature removal of the deciduous teeth, and in that way lessen the many evils arising from such summary treatment. In commencing this article, it was my intention to have enumerated some of these evils, and spoken of their connection with, and effect upon, the permanent teeth; but it has already grown to a greater length than admissible. Hoping that it will have the effect to call out other efforts upon this interesting subject, I leave it to abler heads.

C. N. PEIRCE

The above is a very interesting paper, and we hope our contributor will favor us again.

J.D.W.

State Unit Secretaries

ALABAMA: Dr. A. A. Parden, 350 Weirackee Ave., Mobile, Alabama.

ARIZONA: Dr. Richard Le Sueur, 16 N. Hibbert, Mesa, Arizona.

ARKANSAS: Dr. Basil W. Gibbs, Box 6, Star City, Arkansas.

CALIFORNIA—North: Dr. Lee R. Winters, 2903 Salvio St., Concord, California.

CALIFORNIA—SOUTH: Miss Lorraine Duncan, *Executive Secretary*, 3780 Wilshire Blvd., Los Angeles 5, California.

COLORADO: Dr. J. M. Eisenson, 8790 West Colfax Ave., Lakewood 15, Colorado.

CONNECTICUT: Dr. Naomi A. Dunn, 24 Washington St., New Britain, Connecticut.

DISTRICT OF COLUMBIA: Dr. E. M. Bouchard, 3900 Reservoir Rd., N.W., Washington, D. C.

FLORIDA: Dr. John Tabak, 1451 N. Bayshore Dr., Miami 32, Florida.

GEORGIA: Dr. William R. Shupert, 1293 Peachtree St., N.E., Atlanta 9, Georgia.

HAWAII: Joseph M. Yamamoto, D.D.S., 2011 N. King St., Honolulu 17, Hawaii.

IDAHO: Dr. Wesley O. Young, Idaho Dept. of Health, 120 N. Capital Blvd., Boise, Idaho.

ILLINOIS: Dr. Ronald Rothenberg, 4801 Church St., Skokie, Illinois.

INDIANA: Dr. E. R. Rothhaar, 516 Johnson Building, Muncie, Indiana.

IOWA: Dr. R. B. Hufford, 417 Fifth St., West Des Moines, Iowa.

KENTUCKY: William C. Reynolds, D.M.D., 1014 N. Limestone, Lexington, Kentucky.

MARYLAND: Dr. John H. Sharpley, 4116 Northern Parkway, Baltimore 6, Maryland.

MASSACHUSETTS: Dr. Melvin H. Gulbrandsen, 3 Seaward Rd., Wellesley Hills, Massachusetts.

MICHIGAN: Dr. Walter Niemann, 216 S. State St., Ann Arbor, Michigan.

MINNESOTA: Dr. Raymond G. Petersen, 621 Winnetka Ave. N., Minneapolis 27, Minnesota.

MISSOURI: Dr. Leo S. Shanley, 7800 Maryland, St. Louis 5, Missouri.

MONTANA: Dr. Fred R. Schwin, P. O. Box 97, Red Lodge, Montana.

NEBRASKA: Dr. Donald H. Stormberg, 4124 Farnam St., Omaha 31, Nebraska.

NEW JERSEY: Dr. Robert E. Brenner, 15 Prince St., Elizabeth, New Jersey.

NEW MEXICO: Dr. I. L. Voda, 1004 Douglas Ave., Las Vegas, New Mexico.

NEW YORK: Dr. Walter R. Woods, 201 Cumberland Pl., Syracuse 10, New York.

NORTH CAROLINA: Dr. Roy L. Lindahl, School of Dentistry, University of North Carolina, Chapel Hill, North Carolina.

OHIO: Dr. S. J. Scaravelli, 5752 Ridge Rd., Cleveland 29, Ohio.

OKLAHOMA: Dr. E. W. Foster, 3832 North May, Oklahoma City, Oklahoma.

ORGEON: Dr. Theodore R. Norman, 2721 N.E. 57th Ave., Portland 13, Oregon.

PENNSYLVANIA: Dr. Benjamin Grossman, 9987 Verree Rd., Philadelphia 15, Pennsylvania.

RHODE ISLAND: Dr. Richard J. Whelan, 1981 Broad St., Cranston 5, Rhode Island.

TENNESSEE: Dr. James P. McKnight, College of Dentistry, University of Tennessee, 847 Monroe Ave., Memphis 3, Tennessee.

TEXAS: Dr. Terry E. Downs, 906 Fredericksburg Rd., San Antonio, Texas.

VIRGINIA: Dr. Charles J. Vincent, Medical College of Virginia, School of Dentistry, 521 North Eleventh St., Richmond 19, Virginia.

WASHINGTON: Dr. John P. Parrish, 307 E. Pioneer, Puyallup, Washington.

WISCONSIN: Dr. F. A. Druse, 9102 W. North Ave., Wauwatosa 13, Wisconsin.

American Society of Dentistry for Children

OFFICERS—1958-59

HAROLD K. ADDELSTON ..... *President*
WILLIAM E. BROWN ..... *President-Elect*
JAMES H. SIMMONS ..... *Vice-President*
RALPH E. MCDONALD ..... *Secretary-Treasurer*
ALFRED E. SEYLER ..... *Editor*

EXECUTIVE COUNCIL

HAROLD K. ADDELSTON
WILLIAM E. BROWN
JAMES H. SIMMONS
RALPH E. MCDONALD
ALFRED E. SEYLER
ALBERT L. ANDERSON
LAWRENCE R. BURDGE '59
VICTOR J. LENCHNER '59
DAVID B. LAW '59
MANUEL M. ALBUM '60
PAUL M. WEBER '60

Executive Secretary—C. F. TUMA, 13201 Miles Ave., Cleveland 5, Ohio

STANDING COMMITTEES

Budget

ALBERT L. ANDERSON, *Chairman* '60
3355 Fourth Avenue, San Diego 3, Calif.
WILLIAM E. BROWN '59
705 N. University Avenue, Ann Arbor, Mich.
LAWRENCE R. BURDGE '62
63 East Front Street, Red Bank, N. J.
GEORGE HIGUE '61
4327 East Gage Avenue, Bell, Calif.
RALPH E. MCDONALD '63
1121 W. Michigan Street, Indianapolis 2, Ind.

Constitution and By-Laws

LAWRENCE R. BURDGE, *Chairman*
63 East Front Street, Red Bank, N. J.
ALFRED E. SEYLER
18557 E. Warren Ave., Detroit 36, Mich.
ALBERT L. ANDERSON
3355 Fourth Avenue, San Diego 3, Calif.

Community Dental Programs

WESLEY O. YOUNG, *Chairman* '61
723 Village Lane, Boise, Idaho
WENDELL WHETSTONE '59
2344 Biscayne Boulevard, Miami, Fla.
RICHARD D. KORNS '60
518 Frisco Building, Joplin, Mo.
ROBERT C. READ '62
2719 W. Santa Barbara, Los Angeles, Calif.
DAVID STRIFFLER '63
State Health Department, P. O. Box 711, Santa Fe, N. M.

Membership

JAMES SIMMONS, *Chairman*
5225 W. Freeway, Fort Worth 7, Texas
NORMAN OLSEN '63
The Dental School, Northwestern University, 311 E. Chicago Avenue, Chicago, Ill.
DAVID L. WEBBER '59
1618 Main Street, Springfield, Mass.
CHARLES SWEET, JR. '60
2940 Summit Street, Oakland 9, Calif.
IRVING W. EICHENBAUM '61
24 Washington Street, New Britain, Conn.
JOHN SHARPLEY '62
4116 Northern Parkway, Baltimore 6, Md.

Professional Relations

H. CURTIS HESTER, *Chairman* '61
855 Bloomfield Avenue, Glen Ridge, N. J.
MYERS THORNTON '63
2921 Fairmount, Dallas, Texas
PAT H. LYDDAN '60
302 Francis Building, Louisville 2, Ky.
ROBERT W. BURCHESKY '59
135 Westminster Place, Utica, N. Y.
B. Z. RABINOWITCH '59
5720 Wilshire Blvd., Los Angeles 36, Calif.

Public Relations and Publicity

MODE R. PERRY, *Chairman* '62
4595 College, San Diego, Calif.
CHARLES E. OXAR '59
7625 N. E. 2nd Avenue, Miami 38, Fla.
WILLIAM E. CODY '60
1325 East 16th Avenue, Denver, Colo.
DEAN HUCHEL '61
10742 Riverside Inn, North Hollywood, Calif.

State Units

WILLIAM E. BROWN, *Chairman*
705 N. University Avenue, Ann Arbor, Mich.
PAUL SYDOW '62
29 Lincoln Street, Framingham, Mass.
RICHARD E. JENNINGS '59
1614 N. Lyndhurst Drive, Speedway, Ind.
JAMES CONDON '63
731 West Indiana, Spokane, Wash.
MELVIN A. NOONAN '61
630 N. Woodward, Birmingham, Mich.
IRWIN I. BEECHEN '60
2929 Summit Street, Oakland, Calif.

Schools and Dental Boards

DOUGLAS J. SANDERS, *Chairman* '61
Baltimore College of Dentistry, University of Maryland, Lombard and Green Streets, Baltimore 1, Md.
DAVID B. LAW '62
812 General Insurance Bldg., Seattle 5, Wash.
WILLIAM S. KRAMER '63
University of Nebraska School of Dentistry, Lincoln 8, Nebr.
ARTHUR M. MICKLER '59
1974-A Douglas Boulevard, Louisville, Ky.
FRANCIS I. FLEEGE
Marquette University Dental School, Milwaukee, Wis.

Editorial and Publications

MANUEL M. ALBUM, *Chairman* '59
Medical Arts Building, Hillside Avenue and New York Road, Jenkintown, Pa.
GORDON H. ROVELSTAD '60
3244 Harrison Street, Evanston, Ill.
BASIL BIBBY '61
Eastman Dental Dispensary, 800 Main Street, Rochester, N. Y.

Abstracts

INCIDENCE OF FRACTURED ANTERIOR TEETH AS RELATED TO THEIR PROTRUSION—T. E. Lewis, Angle Orthodontics, April 1959.

There is a greater incidence of fracture in thirteen-year-olds than in eight-year-olds and it seems reasonable to assume that this difference results from a longer period of exposure to accident.

Three hundred forty-three children between the ages of eight and thirteen years were examined in a public school of San Jose, California. In each child the degree of protrusion of anterior teeth (if any) was noted, as well as the presence or absence of fractures in anterior teeth; if fractured anterior teeth were found, the severity was noted. Fractures were designated as mild if only the enamel of the tooth was involved, all other fractures were recorded as severe. Statistical analysis of the data by means of the Chi Square test suggests that there is a real relationship between the incidence of fractured anterior teeth and the protrusion of those teeth, a relationship which should not be ascribed to chance alone.

HUGH M. KOPEL

MULTIPLE SCLEROSIS IN CHILDREN—A CLINICAL STUDY OF 40 CASES WITH ONSET IN CHILDREN—J. C. Gall, Jr.; A. B. Hayles; R. G. Sickert, and H. M. Keith, M.D., Jr. Pediatrics, 21:703-709, May 1958.

Forty children were observed in the Mayo Clinic, Rochester, Minnesota, between 1920 and 1952 whose clinical disturbances showed they had multiple sclerosis. Eighteen of these were less than 15 years when seen, the remainder between 15 and 20 years when a diagnosis was made, but symptoms began before age 15.

Diagnostic criteria were multiple symptoms and signs due to lesions of c.n.s. No postmortem confirmation of clinical diagnosis was feasible. Disease did not differ clinically from the adult. The onset was gradual with an initial episode of impaired neurologic functioning followed by a symptom-free period of several years.

The authors found that the most common symptoms were disturbed function of a limb, visual disturbances, local numbness, tingling vertigo, dizziness, headache or vomiting. Nearly all of the patients observed complained of incoordination, muscle weakness and disturbances of sphincter function. Pain was found to be unusual.

On the follow-up basis the article goes on to say that 32 patients were still ambulatory, 10 bedfast, 12 had died from illness or complication. The average life of the 12 patients who died was 14 years from the time of the onset of symptoms. Most were bedfast for several years terminally.

It should be recognized that multiple sclerosis though rare in children does occur and must be kept in mind when obscure signs of a central nervous system origin are displayed. Visual disturbances are important and a diagnosis may be strongly suggested if the symptoms occur following a similar episode, no matter what the time lapse is between episodes.

MANUEL M. ALBUM

Book Review

CLINICAL DENTAL HYGIENE, edited by Shailer Peterson, B.A., M.A., Ph.D. Index, Glossary. St. Louis, C. V. Mosby Co., 1959. 323 p. Price $6.75.

The writings and teachings of eighteen persons have been integrated and edited by Shailer Peterson to produce this book. It is intended as a basic text for the dental hygiene curriculum.

The introductory chapter provides the reader with an historical, statistical, and enlightening approach to dental hygiene and describes the role of the dental hygienist in a dental office.

One bright spot of the text is found in the chapter on radiography, which is excellent. It includes the history, theory, and technic of radiography and this material is well presented. The chapters on toothbrushing and case histories are done very well.

Because dental hygiene embraces phases of dentistry, dental assisting, office administration, patient handling, and other related things, the editor has included all of these facets under one cover in an attempt to provide the dental hygiene profession with their own text. Many of these aspects of dental hygiene are a course in themselves and hence an entire text could be devoted to any one of them. Consequently, in the space afforded the editor of necessity had to limit this text to the salient points.

Dr. Peterson has compiled a comprehensive tome on dental hygiene, the reading of which to its greatest advantage will necessitate supplemental reading in most of the areas covered.

PIERCE A. MCLEAN

Pedodontist Wanted
Florida Licensed
Board Qualified

Pedodontist badly needed in West Coast city of 100,000 which now has only one other man doing pedodontics. Fast-growing community assures busy practice immediately. Highly desirable area in which to live, with top-quality office designed for pedodontics available immediately. Office building houses nine other physicians and dentists, all specialists.

Box 912
The American Society of Dentistry
For Children
13201 Miles Avenue
Cleveland 5, Ohio

phas-
office
and
as in-
one
den-
own
al hy-
and
ed to
n the
essity
alient

mpre-
the
dvan-
read-

AN